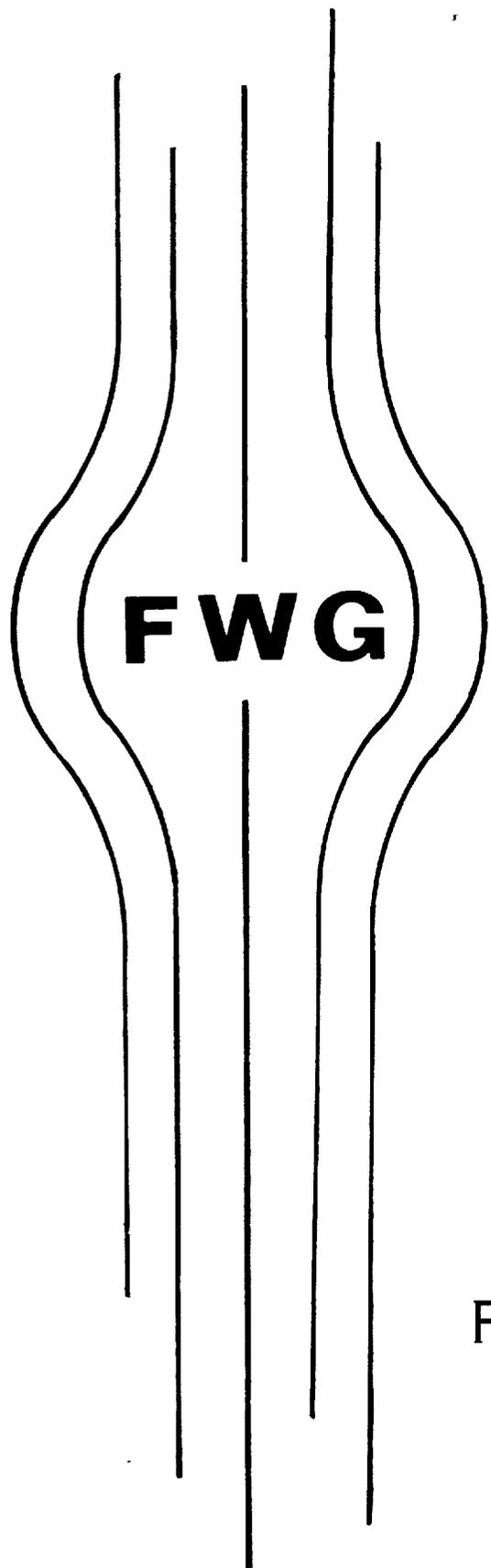


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CR-184084

**INTERIM FINAL REPORT**  
**Contract NAS8-37377**

November 30, 1990



**ANALYSIS OF WIND PROFILE  
MEASUREMENTS FROM AN  
INSTRUMENTED AIRCRAFT**

**FWG ASSOCIATES, INC.**  
*"Continuity with the Future"*

(NASA-CR-184084) ANALYSIS OF WIND PROFILE  
MEASUREMENTS FROM AN INSTRUMENTED AIRCRAFT  
Interim Final Report (FWG Associates)  
159 p

N91-16523

CSCL 04B

Unclass

G3/47 0325626

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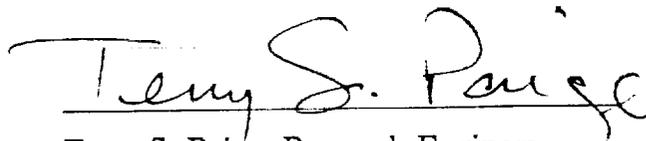
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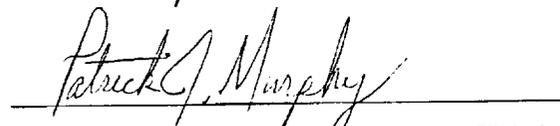
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MEASUREMENTS FROM AN  
INSTRUMENTED AIRCRAFT

November 30, 1990

Approved:

  
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## 1.0 INTRODUCTION

This report documents the results of an experimental program to determine the capability of measuring wind profiles in support of STS operations with an instrumented aircraft. The report is primarily a compilation of the flight experiments and the statistical data comparing the quality of the aircraft measurements with quasi-simultaneous and quasi-spatial overlapping Jimsphere measurements. Parts of this study have been reported by Bjarke and Ehernberger [1], Haering [2], and Hill [3]. The study was prompted by the deficiency in the presently used Jimsphere/radar system of the long lead time (2 hours) necessary between the release of the Jimsphere and the STS launch. By making the measurement of winds aloft nearer to the STS launch time, the uncertainty in the wind profile at the time of the launch is reduced, thus potentially reducing the possibility of an unnecessary launch delay due to predicted winds aloft. An instrumented aircraft was chosen as a potential alternative to the Jimsphere/radar system for expediting the wind profile calculation by virtue of the ability of an aircraft to traverse the altitudes of interest (sea level to 18 km above sea level (ASL)) in roughly 10 minutes.

Aircraft have been proven as reliable platforms for making measurements from which wind velocity can be calculated in numerous atmospheric and aircraft response studies [4], but never with the trajectory necessary to calculate wind profiles for space vehicle support. Even though other aircraft were studied and recommended to support this experimental program [3], an F-104 from Dryden Flight Research Facility (DFRF) was initially instrumented and flown. Near the end of the program, an ER-2 from Ames Research Center (ARC) that was fully instrumented for atmospheric research [5] was also tested for potential STS support. Calculated wind profiles based on measurements made from both the F-104 and ER-2 were validated by comparison to wind profiles determined from the trajectories of quasi-simultaneous Jimsphere releases. Data for comparison was collected at both DFRF

and Kennedy Space Center (KSC).

In this report, brief descriptions of the Jimsphere/radar system, the F-104 instrumentation and data acquisition system (DAS), and the ER-2 meteorological measurement system (MMS) are given. Some data reported by Bjarke and Ehernberger [1] are documented here, with data and comparisons previously unreported. Conclusions are made based on the data comparisons, and recommendations are given regarding the viability of using an aircraft for winds aloft measurements in support of STS launches.

## 2.0 INSTRUMENTS AND CALCULATIONS

### 2.1 Jimsphere/Radar

The Jimsphere/radar system consists of a Jimsphere, a two meter diameter helium balloon with the outer skin surface "roughened" by multiple cones, an FPS-16 radar, and a supporting digital computer for data reduction. The balloon is released and tracked from sea level to approximately 18 km ASL, where the balloon explodes. The balloon rises at approximately 5 m/s and is assumed to have a zero slip velocity with the horizontal wind. Thus the horizontal velocity of the Jimsphere, which is determined by the differentiation of the Jimsphere position according to the radar measurements, is assumed to be the horizontal velocity of the wind at the altitude of the Jimsphere. For the purposes herein, the instantaneous winds calculated from Jimsphere trajectories were averaged over 25 m altitude intervals. The calculations used in the Jimsphere data reduction to obtain instantaneous winds, averaged winds, and the uncertainty in those calculations are reported by Hill [3] and Luers and MacArthur [6].

### 2.2 Aircraft

Aircraft have previously been used as platforms for wind measurements for NASA research as well as for research sponsored by other government agencies [7]. The wind vector calculation based on airborne measurements requires the determination of the air velocity relative to the aircraft, the attitude of the aircraft relative to the earth, and the velocity of the aircraft relative to the earth (or the aircraft ground speed). The air velocity relative to the aircraft is transformed by rotation, through the inertial attitude of the aircraft, and by velocity, through the aircraft ground speed. This calculation and its primary variables are described in more detail by Lenschow [8] and numerous other sources.

The aircraft data were reduced to obtain wind velocities and then averaged over 25 m intervals by the process shown on the flowchart in Figure 2.1. The aircraft data

filtering process emulates the smoothing process of winds aloft for 25 m intervals by the combination of the Jimsphere and the ROSE code, shown in Figure 2.2 from Luers and MacArthur, [6]. Because the ascent rate of the aircraft can vary significantly (the F-104 typically climbs at 1500 m/min below 10 km ASL and at 5000 m/min above 10 km ASL,) the time domain filter weights are continually recalculated to filter wind fluctuations according to the response shown in Figure 2.3.

The low pass filter gain function given by Graham [9] is defined by

$$G(f) = \begin{cases} 1 & ; f < f_c \\ \frac{1}{2} [\cos(\frac{f-f_c}{f_t-f_c}\pi) + 1] & ; f_c < f < f_t \\ 0 & ; f > f_t \end{cases} \quad (2.1)$$

where  $G(f)$  is the frequency dependent gain of the filter,  $f$  is the frequency,  $f_c$  is the cut-off frequency, and  $f_t$  is the termination frequency.

The discrete weights calculated by Equation (2.1) are realized in the time domain through the inverse Fourier transform by:

$$h(n\Delta t) = \frac{\pi}{2n\Delta t} \frac{\sin(2\pi f_t n\Delta t) + \sin(2\pi f_c n\Delta t)}{\pi^2 - 4\pi^2(f_t - f_c)^2(n\Delta t)^2} \quad (2.2)$$

where  $h$  is the time dependent gain of the filter,  $n$  is the number of discrete time steps from a central time, and  $\Delta t$  is the discrete time between data samples. Additionally, the weights calculated from Equation (2.2) are multiplied by a Hamming window function given by Ziemer, et al. [10]:

$$w_h(n) = 0.54 + 0.46 \cos \frac{\pi n}{N}, -N \leq n \leq N \quad (2.3)$$

where  $w_h$  is the time dependent gain of the Hamming window, and  $N$  is the number of one sided filter weights ( $2N + 1$  is the total number of weights).

The smoothed winds are calculated by discrete convolution of the product of Equation (2.2) and Equation (2.3) with the instantaneous winds. The gain of the

resultant filter weights from the product of Equation (2.2) and Equation (2.3) is

$$\widehat{G}(f) = h_o + 2 \sum_{i=1}^N h_i \cos(2\pi f_i \Delta t) \quad (2.4)$$

where  $\widehat{G}(f)$  is the frequency dependent filter gain,  $h_o$  is the filter center weight, and  $h_i$  is the  $i^{\text{th}}$  filter weight.  $N$  was chosen herein arbitrarily as 99.

The filter cut-off and termination wavelengths were chosen as 200 and 20 meters, respectively, to best fit the 25 meter interval smoothing response of Figure 2.2. The resulting wavelength response of the filter is also shown in Figure 2.2.

The cut-off and termination wavelengths are transformed to cut-off and termination frequencies by the ascent rate of the aircraft through

$$f_c = \dot{z} / \lambda_c \quad (2.5)$$

$$f_t = \dot{z} / \lambda_t \quad (2.6)$$

where  $f_c$  and  $f_t$  are the filter cut-off and termination frequencies,  $\lambda_c$  and  $\lambda_t$  are the filter cut-off and termination wavelengths, and  $\dot{z}$  is the aircraft ascent rate. Figure 2.3 shows sample frequency responses of the adaptive filter for varying aircraft ascent rates.

### 2.3 F-104

The F-104 high performance fighter aircraft was fitted with instrumentation originally intended for this experimental program. The F-104 is able to collect the data for the calculation of two-step profiles from sea level to 18 km ASL in approximately 10 minutes. A typical flight path for data collection begins with the F-104 flying at a high subsonic Mach number to an altitude of 10 km ASL (typically at  $Ma = 0.9$ ), then maneuvering to gain airspeed and flying from 10 km ASL to 18 km ASL supersonically (typically between  $Ma = 1.6$  and  $Ma = 2.0$ ).

The major components of the instrumentation on the F-104 for wind vector calculation support are a NACA standard air data probe and a Litton strap down

inertial navigation system (INS). The NACA air data probe provides the measurements used to determine the airspeed of the F-104 and the air flow angles relative to the F-104 (angle-of-attack and angle-of-sideslip). The INS provides measurements of the inertial attitude and the ground speed of the F-104. Radar tracking has also been used to determine the ground speed of the F-104 for the wind velocity calculations as reported by Hill [3].

The wind profiles calculated using the ground speeds provided by both the INS and the radar measurements are presented herein. The instrumentation on the F-104, the DAS, and calculations are discussed in more detail by Bjarke and Ehernberger [1]. Calibration of the instrumentation and corrections made to the measurements are discussed by Haering [2]. The uncertainty of the wind velocity calculations from the F-104 based measurements is also discussed by Haering [2].

#### **2.4 ER-2**

The ER-2 is a low speed jet which flies from sea level to 18 km ASL subsonically without additional maneuvering at intermediate altitudes. The ER-2, a successor to the U-2, is used by NASA for high altitude atmospheric research [4]. The ER-2 was not originally intended to be used in this experimental program, but the necessity of calculating broken profiles with the F-104 data prompted the trial use of the ER-2.

The most notable difference between the instrumentation on the ER-2 and the F-104 for wind velocity calculations is the use of differential pressure measurements on the radome of the ER-2 for the determination of angle-of-attack and sideslip angle. The ER-2 also has an INS which provides the aircraft inertial attitude and ground speed for the wind velocity calculations. Radar measurements have not been used to determine the ground speed of the ER-2 for wind velocity calculations. The ER-2, instrumentation, DAS, and calculations are discussed in detail by Scott, et al. [5].

The data from the ER-2 MMS includes the geopotential altitude, calculated

from the measured ambient pressure and the 1976 U.S. Standard Atmosphere [7]. Because the winds calculated from Jimsphere trajectories are referenced to the geometric altitude of the Jimsphere, calculated from the radar track of the Jimsphere, the geopotential altitudes in the ER-2 MMS data were converted to geometric altitudes for the comparison of the Jimsphere calculated winds and the ER-2 MMS calculated winds. The conversion was based on

$$dZ = \frac{-dp}{g\rho} \quad (2.7)$$

where  $Z$  is the geometric altitude,  $p$  is the ambient pressure,  $g$  is the gravitational acceleration, and  $\rho$  is the mass density of air. In these conversions,  $g$  was considered constant and  $\rho$  was calculated by perfect gas relations and dry air assumptions.

At the lowest geopotential altitude in a profile,  $h_o$ , the initial geometric altitude,  $Z_o$ , is calculated from

$$Z_o = h_o \frac{dZ}{dh} \quad (2.8)$$

where  $\frac{dZ}{dh} = \dot{Z}/\dot{h}$ ,  $\dot{h}$  is calculated from numerical differentiation of the ER-2 MMS geopotential altitude data,  $\dot{Z} = \frac{\dot{p}}{g\rho}$ , and  $\dot{p}$  is calculated from numerical differentiation of the ambient pressure. This calculation assumes that the geopotential altitude is proportional to the geometric altitude from sea level to the lowest altitude in the ER-2 MMS data, and that the geometric altitude and the geopotential altitude are equal at sea level.

Subsequent geometric altitudes are calculated by the summation

$$Z_i = Z_o + \sum_{i=1}^{N-1} \frac{-\Delta p}{g\rho} \quad (2.9)$$

where  $Z_i$  is the calculated altitude of the  $i^{th}$  data sample,  $N - 1$  is the number of data samples in the data set, and  $\Delta p$  is the pressure difference between data samples.

Figure 2.4 shows a sample wind profile calculated from the ER-2 MMS on 20-Jul-89 at Dryden Flight Research Facility, referenced to both the geopotential

altitude and the calculated geometric altitude. Also shown is the profile calculated from the trajectory of the first Jimsphere released that day. The profile generated with the ER-2 MMS data and referenced to the calculated geometric altitude is in better agreement with the Jimsphere wind, than the profile referenced to the geopotential altitude.

## 3.0 DATA AND DATA COMPARISONS

### 3.1 Comparison Methodology

In this study, the wind profiles calculated from the Jimsphere trajectories were used as the standard by which the wind profiles calculated from the measurements taken from both the F-104 and the ER-2 were validated. The wind speed, and the north and east wind velocity components calculated from the Jimsphere trajectories were compared to the same calculations from the aircraft data at the same altitudes.

The wind profiles calculated using the data from the different instruments were compared over the entire profiles and on layers 3 km deep. The root-mean-square (RMS) difference of the entire profiles and the 3 km layers are presented herein. The RMS difference of the calculated headings of the winds are also presented.

A wind profile calculated from the aircraft data is considered to be of equivalent quality to a wind profile calculated from a Jimsphere trajectory if the RMS difference of the profiles is less than 2.5 m/sec and the RMS differences of each of the layers is less than 3.0 m/sec. The criteria of the 2.5 and 3.0 m/sec RMS differences is based on studies of profiles from Jimsphere pairs released with both spatial and temporal differences. The justification for this criteria is given by Hill [3].

### 3.2 F-104 and Jimspheres

The early flights of the F-104 at DFRF were entirely subsonic and at altitudes less than approximately 13 km ASL. Some early flights of the F-104 are documented in [3] and will be discussed in the context of the results of the latter flights.

The flights of the F-104 with supersonic airspeeds were typically made in six legs: a subsonic climb to 10 km ASL, a subsonic climb from 10 to 15 km ASL, a subsonic descent from 15 to 10 km ASL, during which no data was taken, a supersonic climb from 10 to 18 km ASL, a supersonic descent from 18 to 10 km ASL, and a subsonic descent from 10 km ASL to sea level. Each of the flight legs is recognized as a break in the calculated wind profile data. The approximate

history of the flights is presented in Figures 3.1 to 3.6, which present the flight paths taken by the F-104 and the time of the F-104 flights in relation to the trajectory of Jimspheres. The wind profiles calculated from the data collected on these flights and from the quasi-simultaneous Jimsphere trajectories are presented in Figures 3.7 to 3.69. The comparisons between the F-104 winds and the Jimsphere winds are presented in Tables 3.1 to 3.18.

### **3.3 ER-2 and Jimspheres**

Some of the profiles presented are incomplete with regard to the data collected by the F-104; this is due to data recognized as “noisy” in the data processing and being rejected. Additionally, the radar tracking data was, at times, in obvious error with regards to the ground speed of the aircraft. Spikes in the calculated wind profiles would often occur from erroneous radar tracking and result in data being rejected.

The ER-2 flew concurrently with the F-104 at DFRF for an initial comparison of the winds calculated using the ER-2 based measurements with the winds calculated from Jimsphere trajectories. The approximate history of the flights is presented in Figure 3.70, which presents the flight paths taken by the ER-2 and the time of the ER-2 flights in relation to the trajectory of Jimspheres. The wind profiles calculated from the data collected on these flights are presented in Figures 3.71 to 3.76. The comparisons between the ER-2 winds and the Jimsphere winds are presented in Tables 3.19 to 3.21.

The ER-2 flew at Kennedy Space Center on July 31, 1989, and again on August 8, 1989, in mock support of the launch of STS-28. The approximate history of the flights is presented in Figures 3.77 and 3.78, which present the flight paths taken by the ER-2 and the time of the ER-2 flights in relation to the trajectory of Jimspheres. The wind profiles calculated from the data collected on these flights and from the quasi-simultaneous Jimsphere trajectories are presented in Figures 3.79 to 3.90.

The comparisons between the ER-2 winds and the Jimsphere winds are presented in Tables 3.22 to 3.25.

## 4.0 RESULTS AND CONCLUSIONS

The calculated winds presented herein, from data taken from both the F-104 and ER-2, agreed with the winds calculated from the quasi-simultaneous Jimsphere trajectories, within the criteria discussed in Section 3.1, by the percentages presented in Table 4.1. These comparisons indicate that the aircraft might be used in place of the Jimspheres for shuttle launch support only if the advantage of measuring winds closer to launch with an aircraft is greater than the loss of data quality for 25 to 50 percent of the 3 km layers.

Some of the discrepancies in the calculated winds may be explained by technical difficulties; for example, INS problems on the ER-2 were attributed to the differences in the calculated winds from the test on 31-Jul-90 at Kennedy Space Center. If data from that test were discounted from the analysis, the remaining ER-2 data compares to the Jimsphere data within the given criteria for 85 percent of the 3 km layers and 77 percent of the profiles. Similar selectivity of the F-104 data also improves the comparisons between the F-104 data and the Jimsphere data. However, such difficulties would have to be accounted for in assessing the capability of an aircraft to gather data for shuttle launches.

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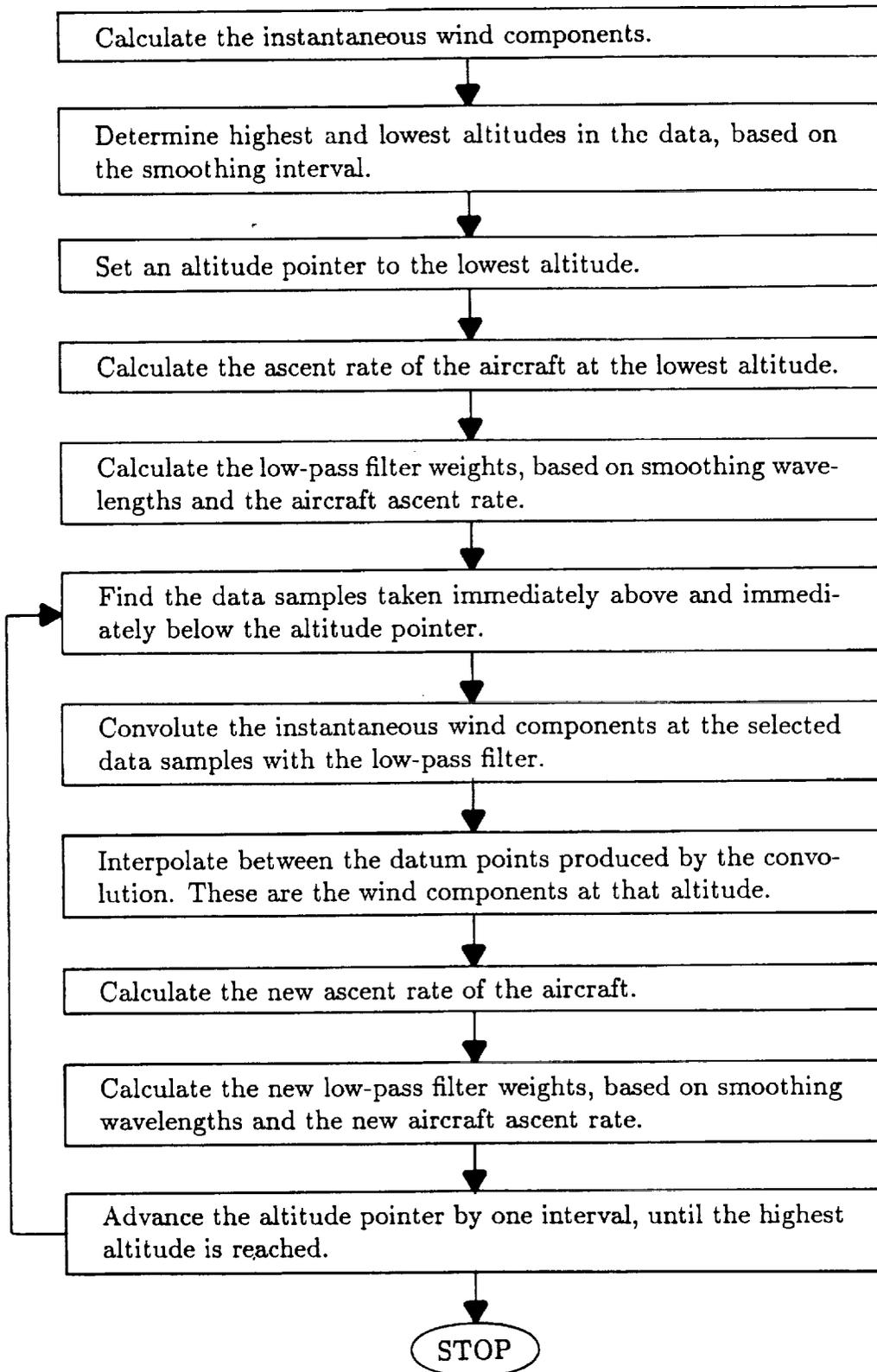


Figure 2.1 Aircraft data smoothing flowchart.

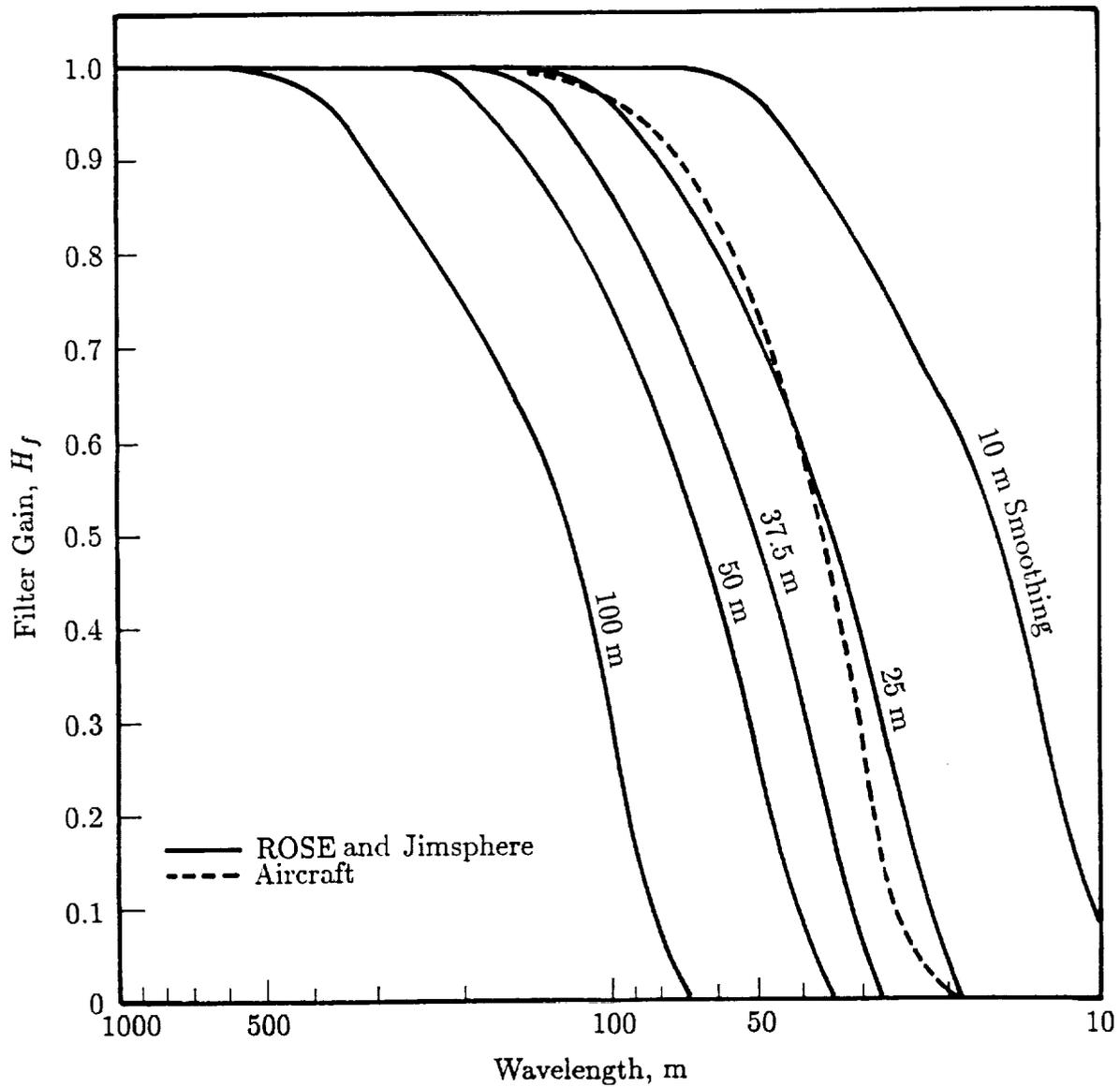


Figure 2.2 ROSE and Jimsphere and aircraft code wavelength response (Adapted from Luers and MacArthur, 1972).

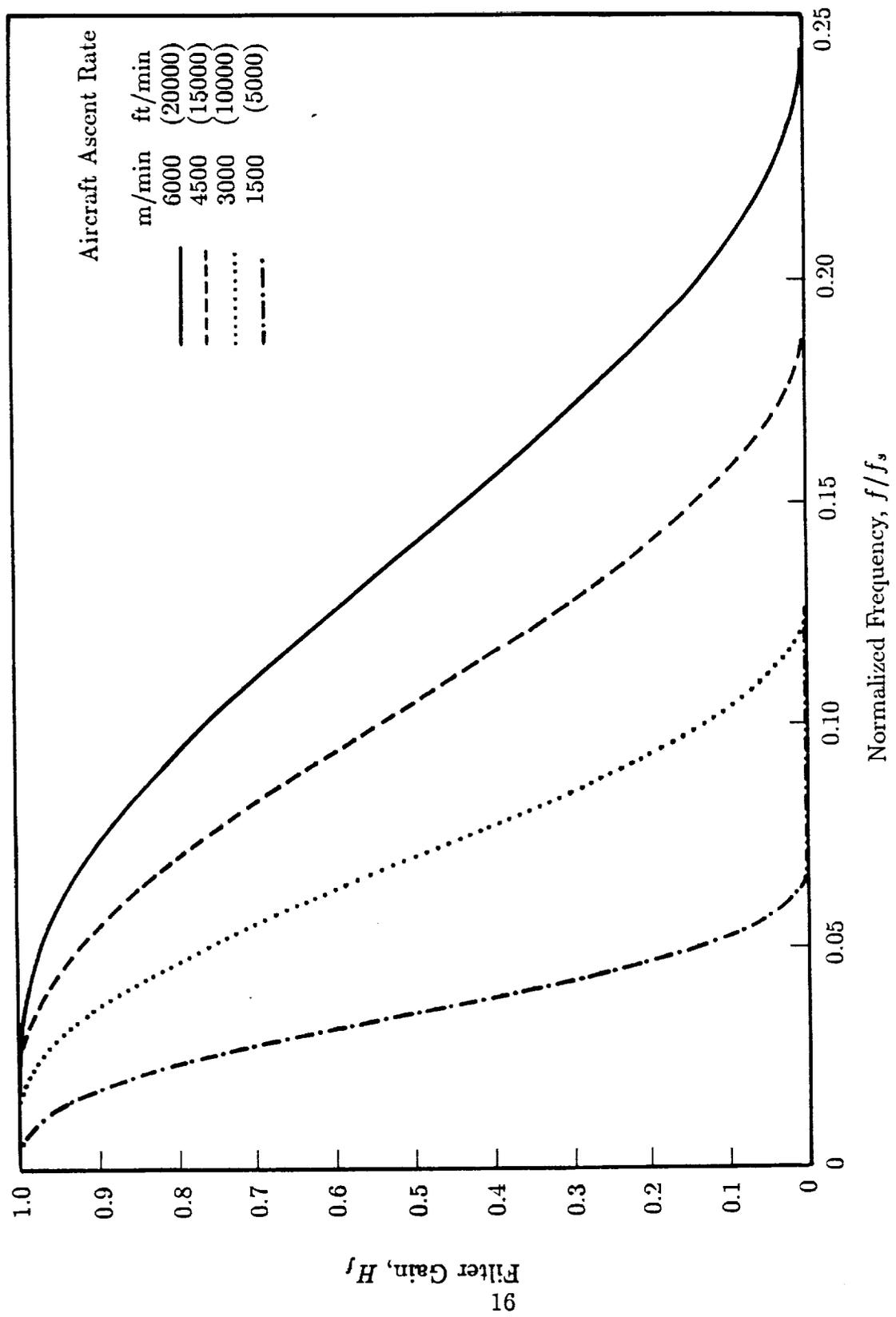


Figure 2.3 Adaption filter frequency response.

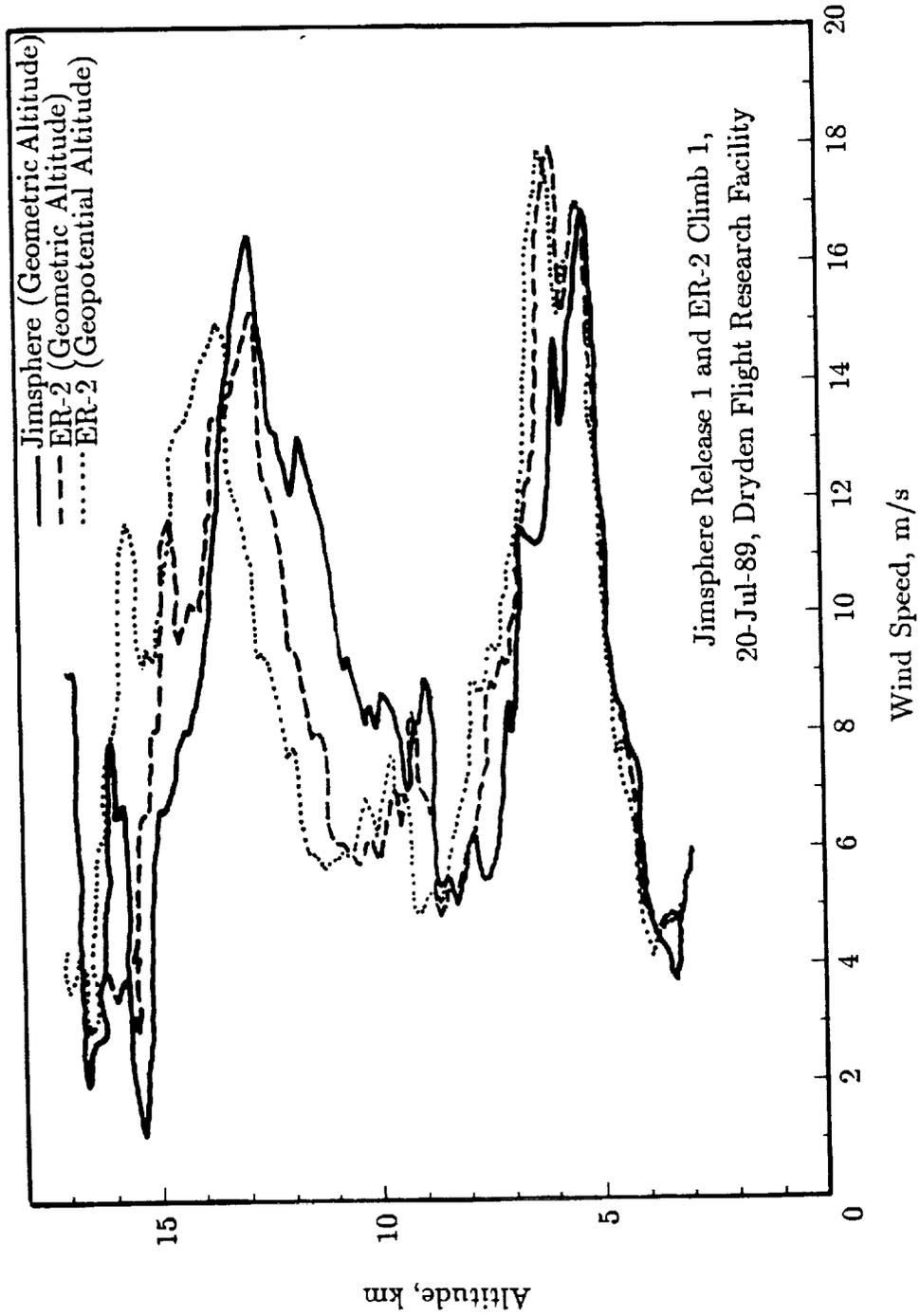
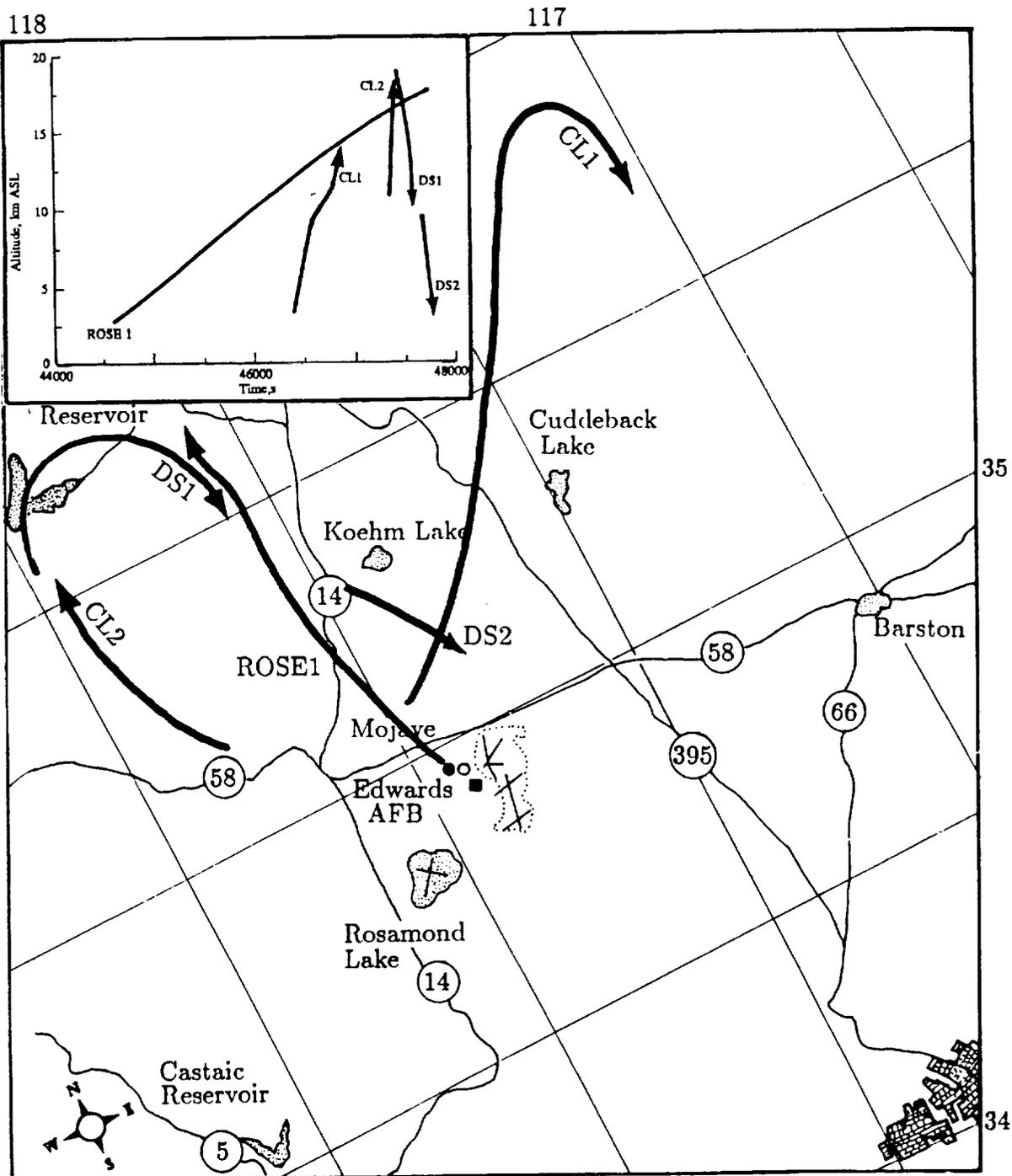
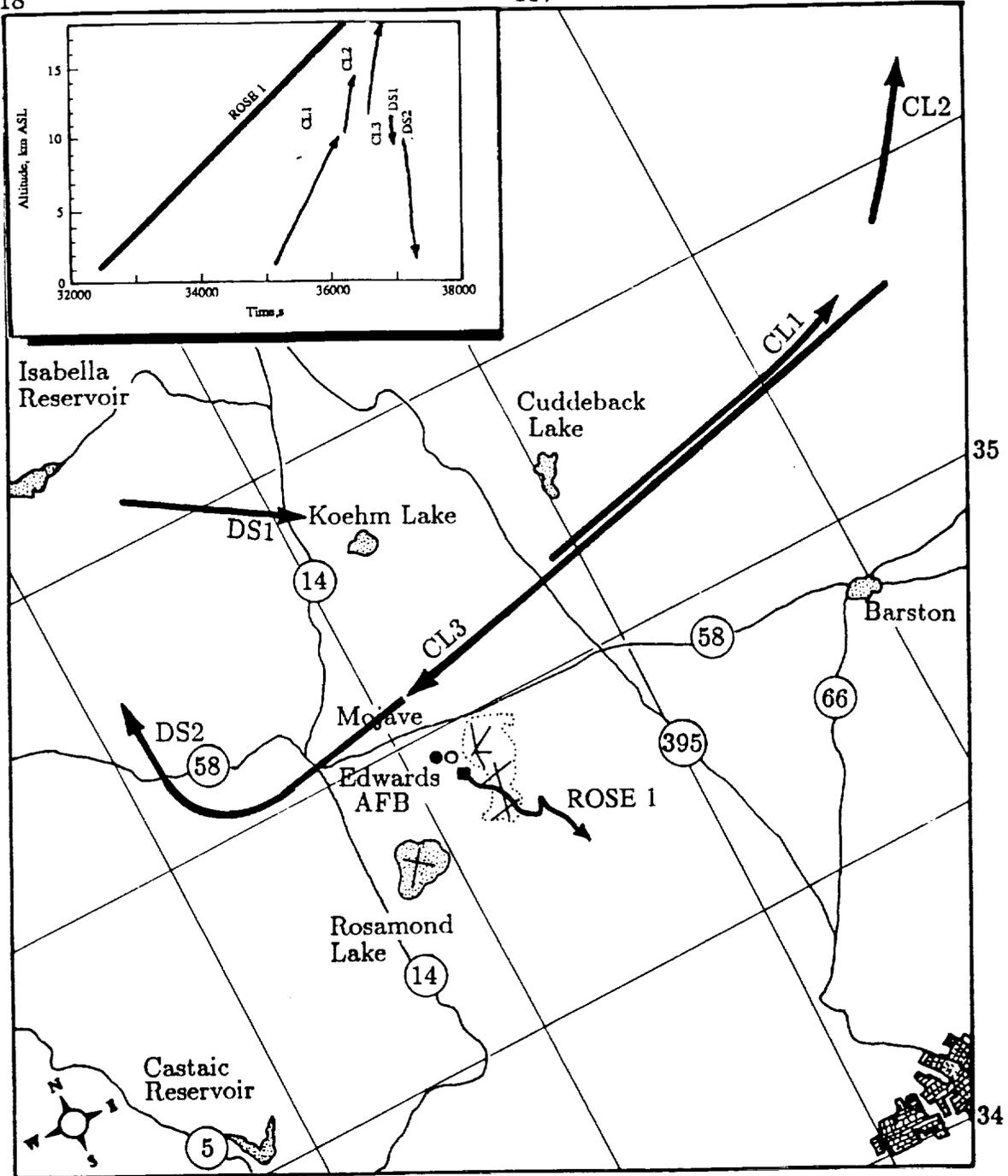


Figure 2.4 Comparison of Jimsphere and ER-2 winds, with both geometric and geopotential altitude.



- Jimsphere/Windsonde/Rawinsonde Release Station, 2300
- FPS -16 38 & 41 2700
- FPS -16 34 & RADAR #5

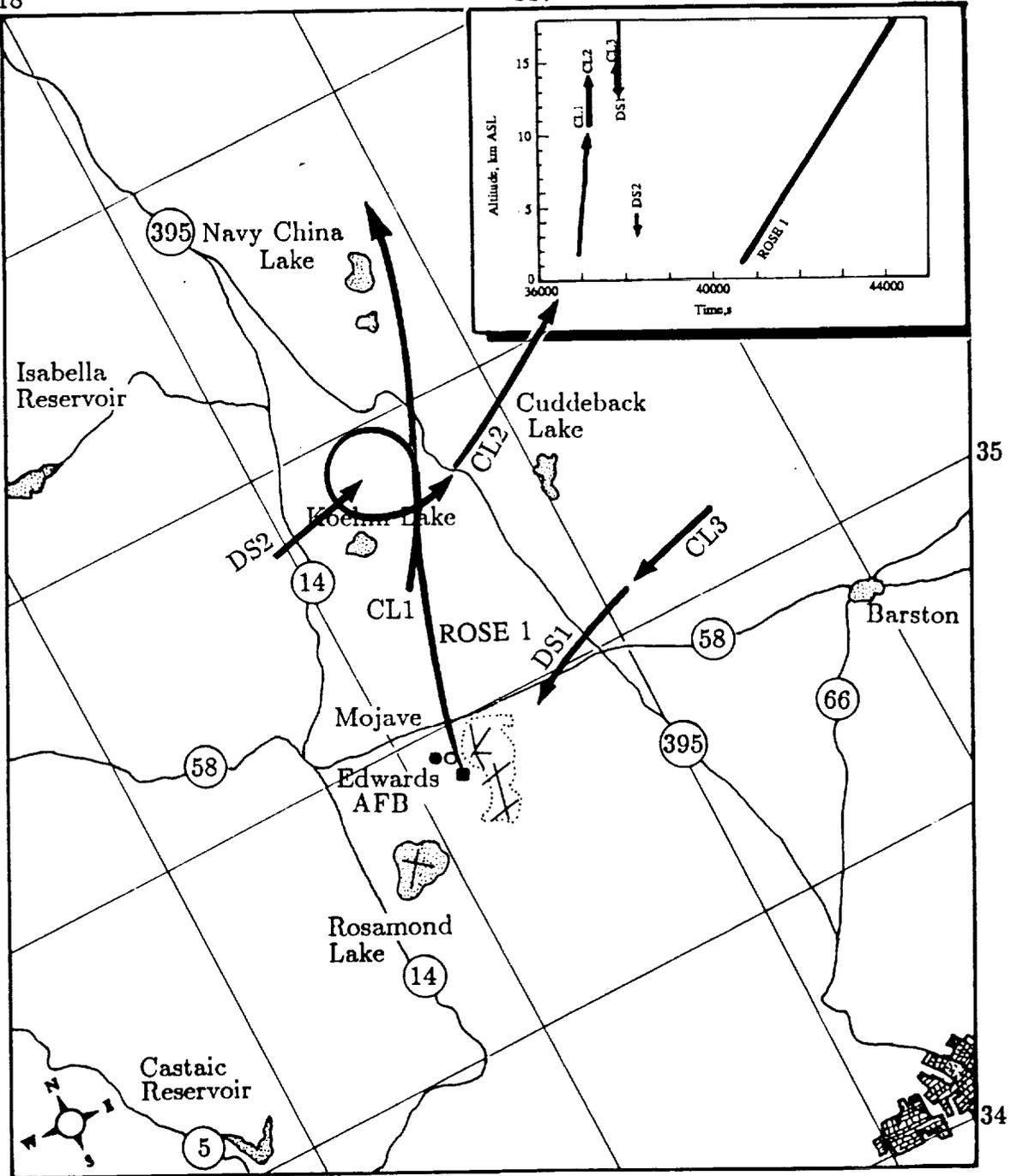
Figure 3.1 Flight 1231 Jimsphere and F-104 paths.



- Jimsphere/Windsonde/Rawinsonde Release Station, 2300
- FPS -16 38 & 41 2700
- FPS -16 34 & RADAR #5

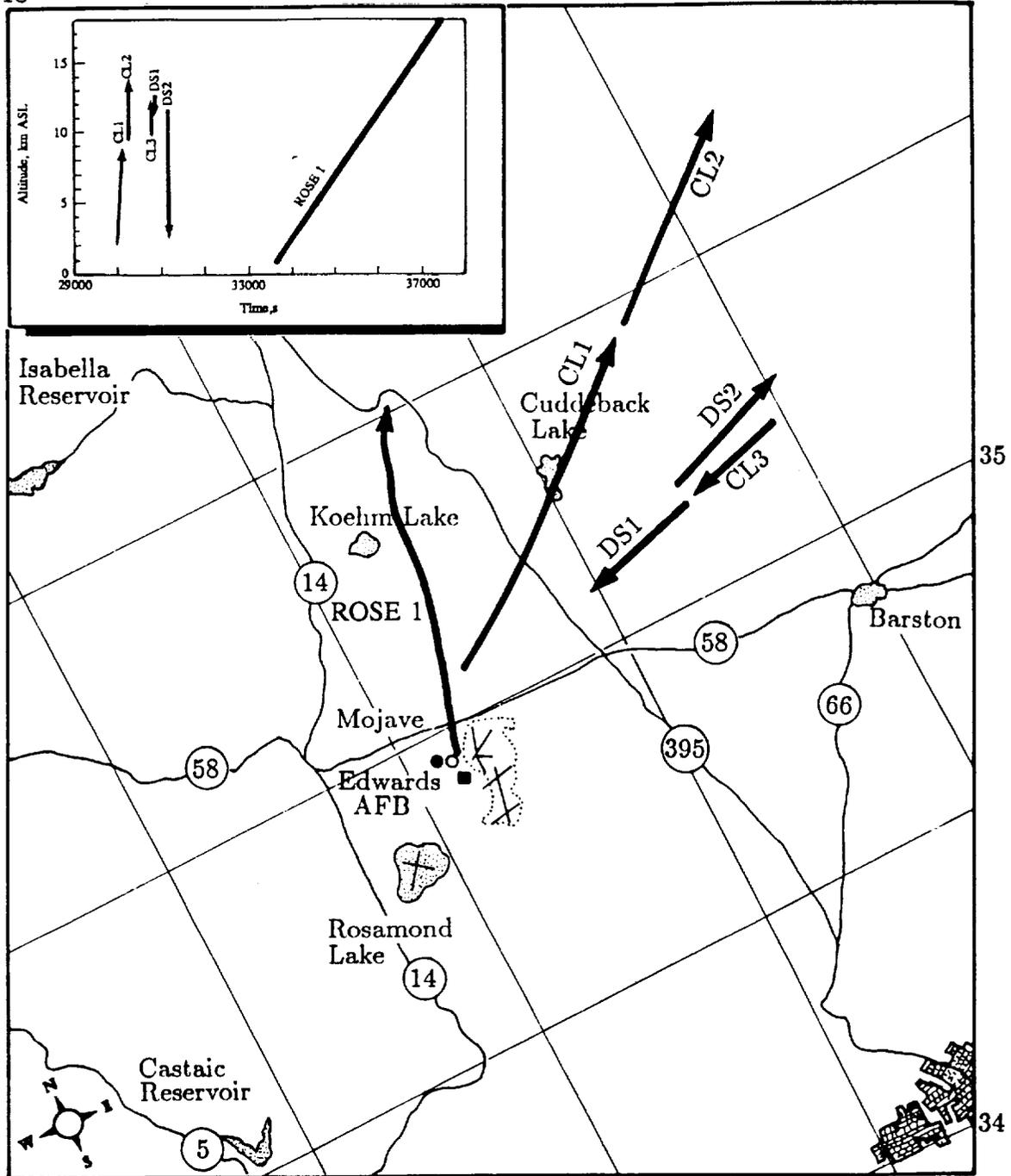
Figure 3.2 Flight 1232 Jimsphere and F-104 paths.





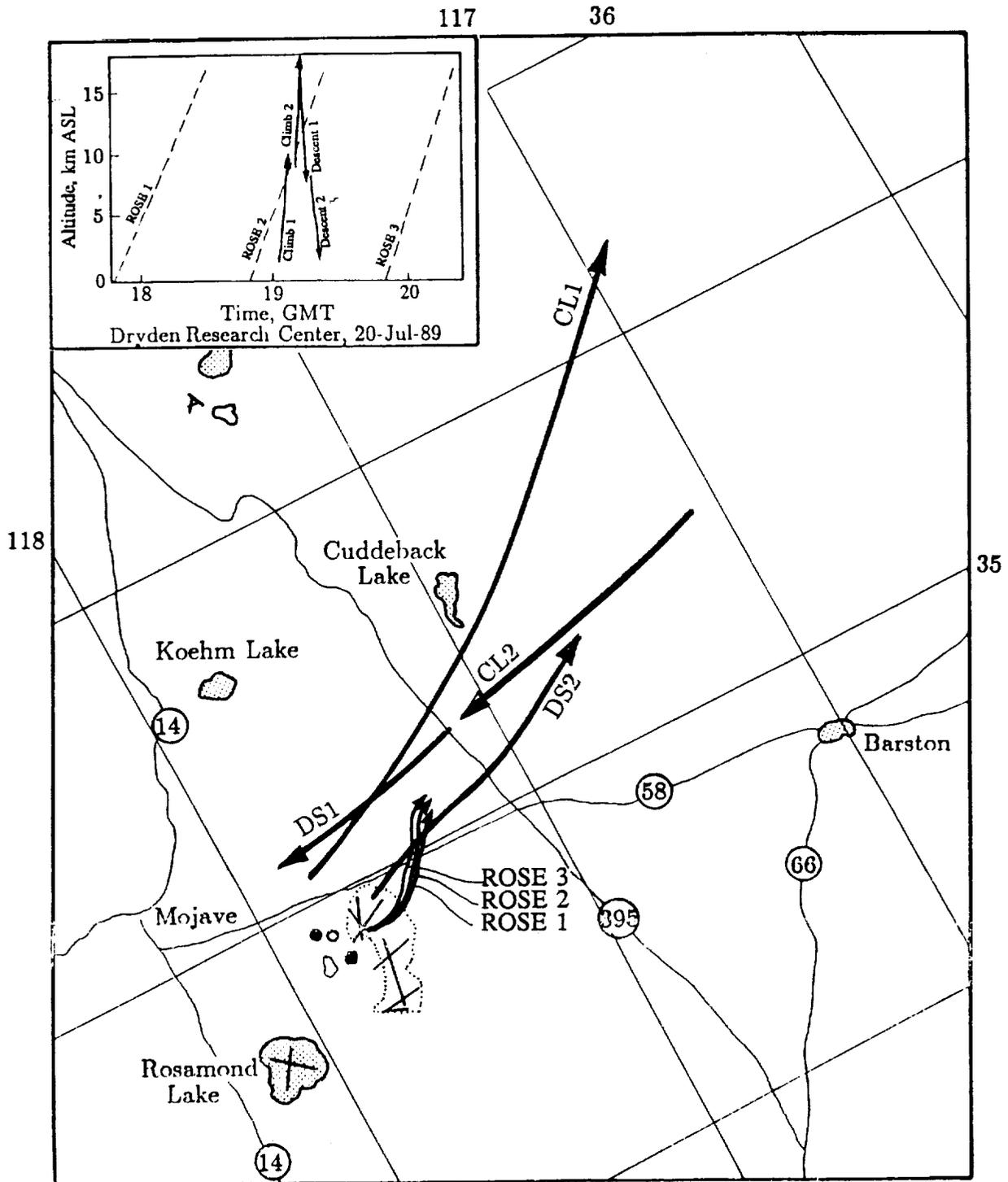
- Jimsphere/Windsonde/Rawinsonde Release Station, 2300
- FPS -16 38 & 41 2700
- FPS -16 34 & RADAR #5

Figure 3.4 Flight 1283 Jimsphere and F-104 paths.



- Jimsphere/Windsonde/Rawinsonde Release Station, 2300
- FPS -16 38 & 41 2700
- FPS -16 34 & RADAR #5

Figure 3.5 Flight 1284 Jimsphere and F-104 paths.



- Jimsphere/Windsonde/Rawinsonde Release Station, 2300
- FPS -16 38 & 41 2700
- FPS -16 34 & RADAR #5

Figure 3.6 Flight 1286 Jimsphere and F-104 paths.

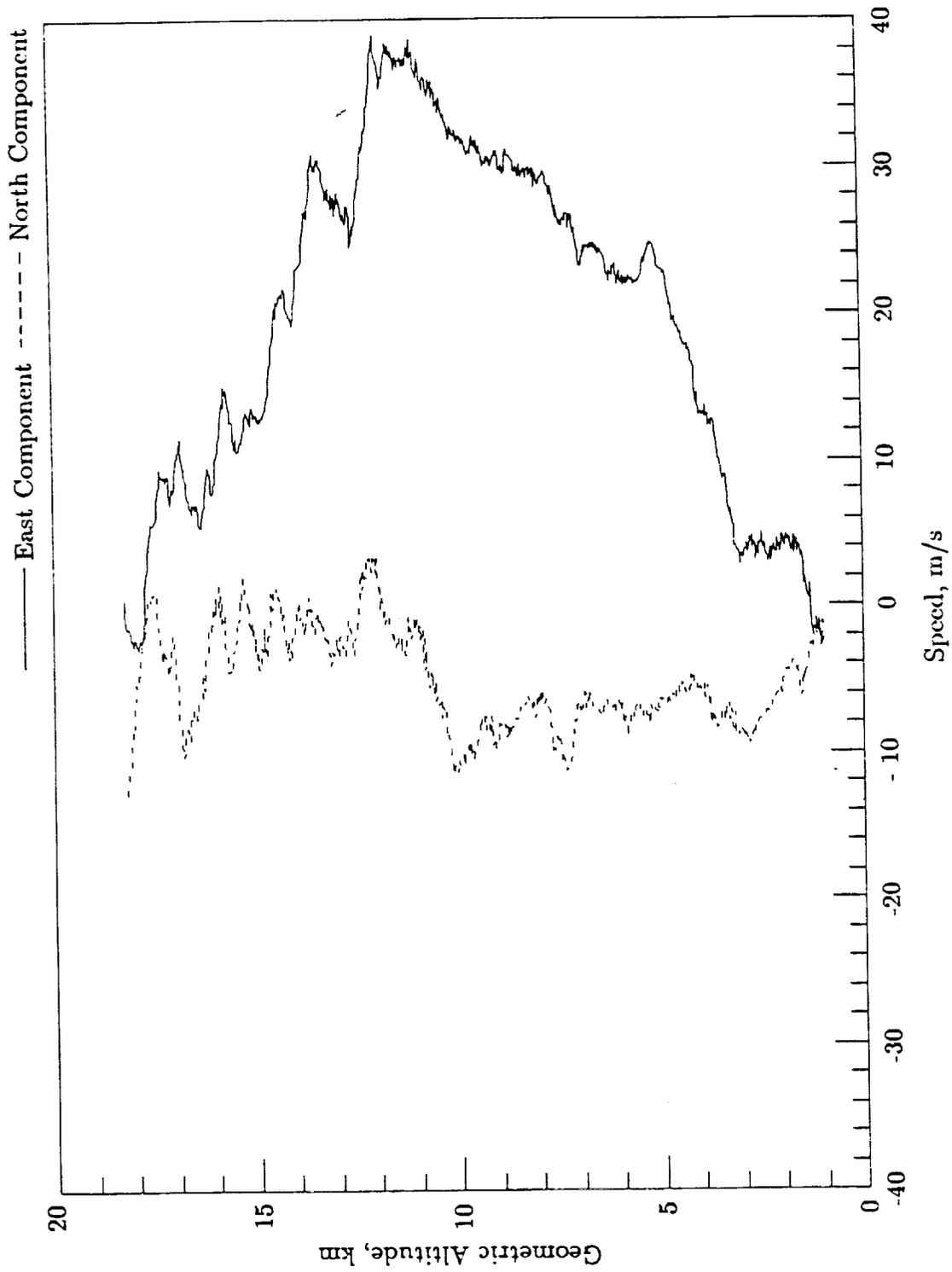


Figure 3.7 Wind velocity horizontal components from Jimsphere  
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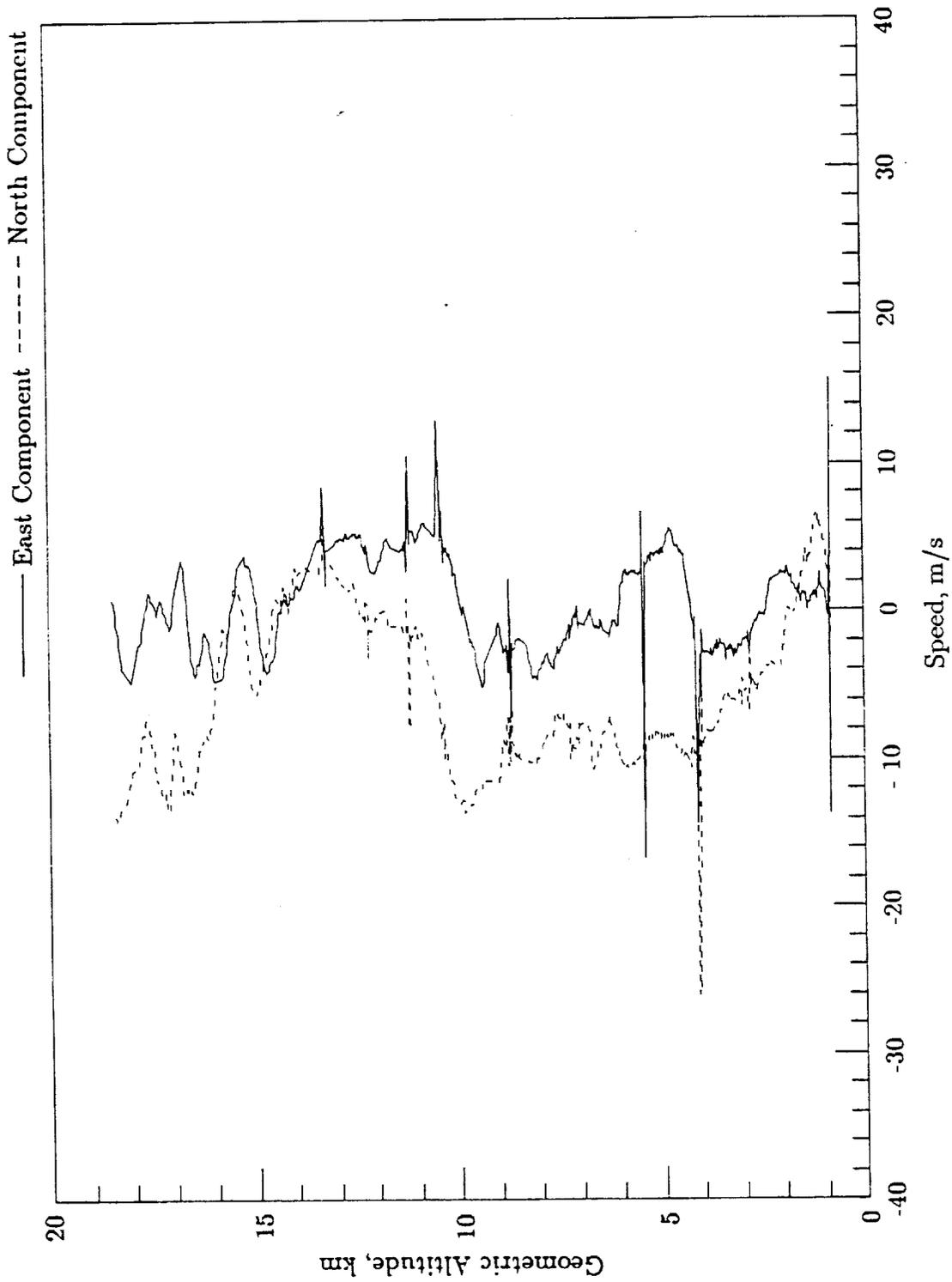


Figure 3.8 Wind velocity horizontal components from Jimsphere Release # 1, 20-Jul-88, Dryden Flight Research Facility.

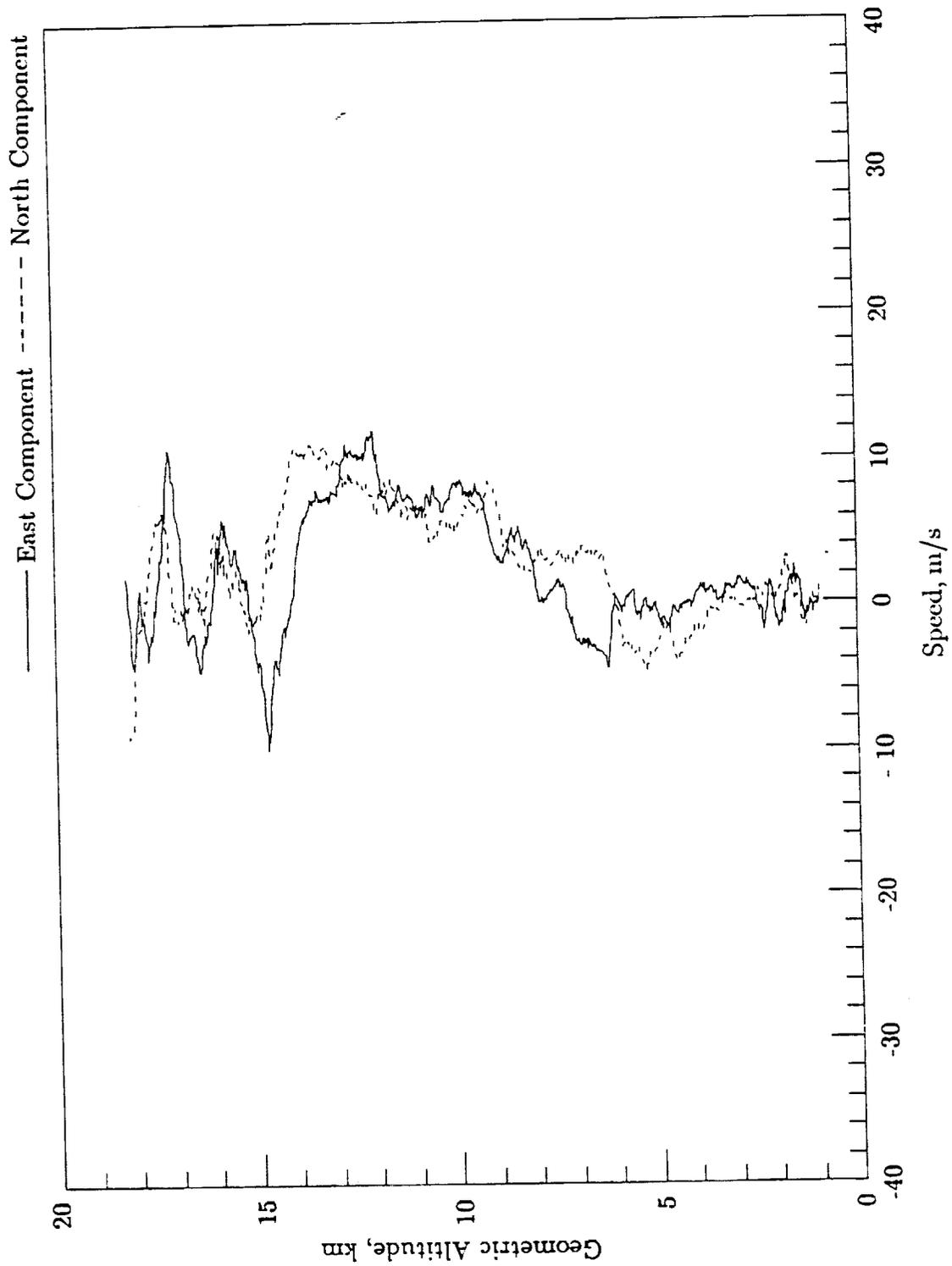


Figure 3.9 Wind velocity horizontal components from Jimsphere  
Release # 1, 01-Aug-88, Dryden Flight Research Facility.

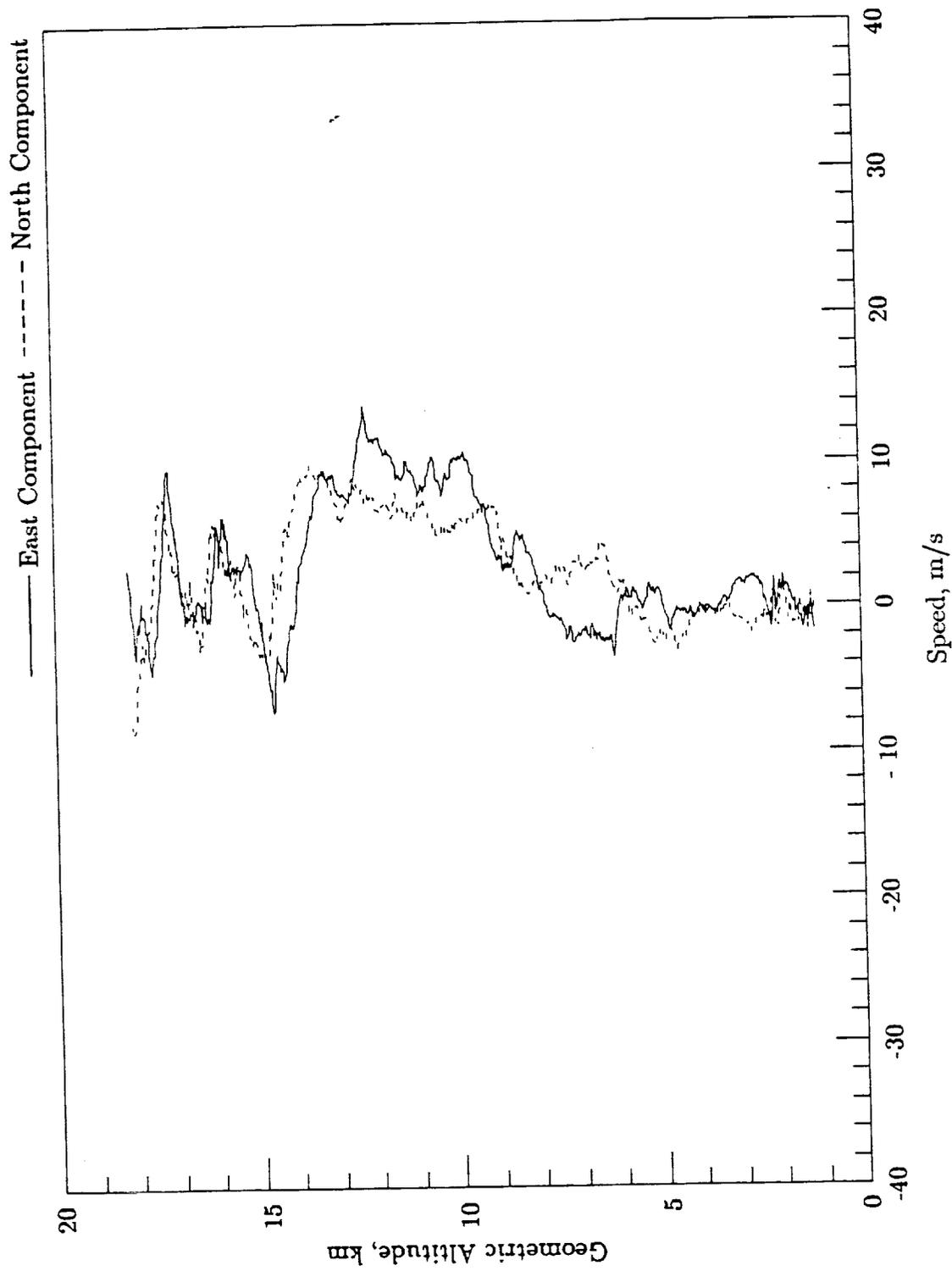


Figure 3.10 Wind velocity horizontal components from Jimsphere Release # 2, 01-Aug-88, Dryden Flight Research Facility.

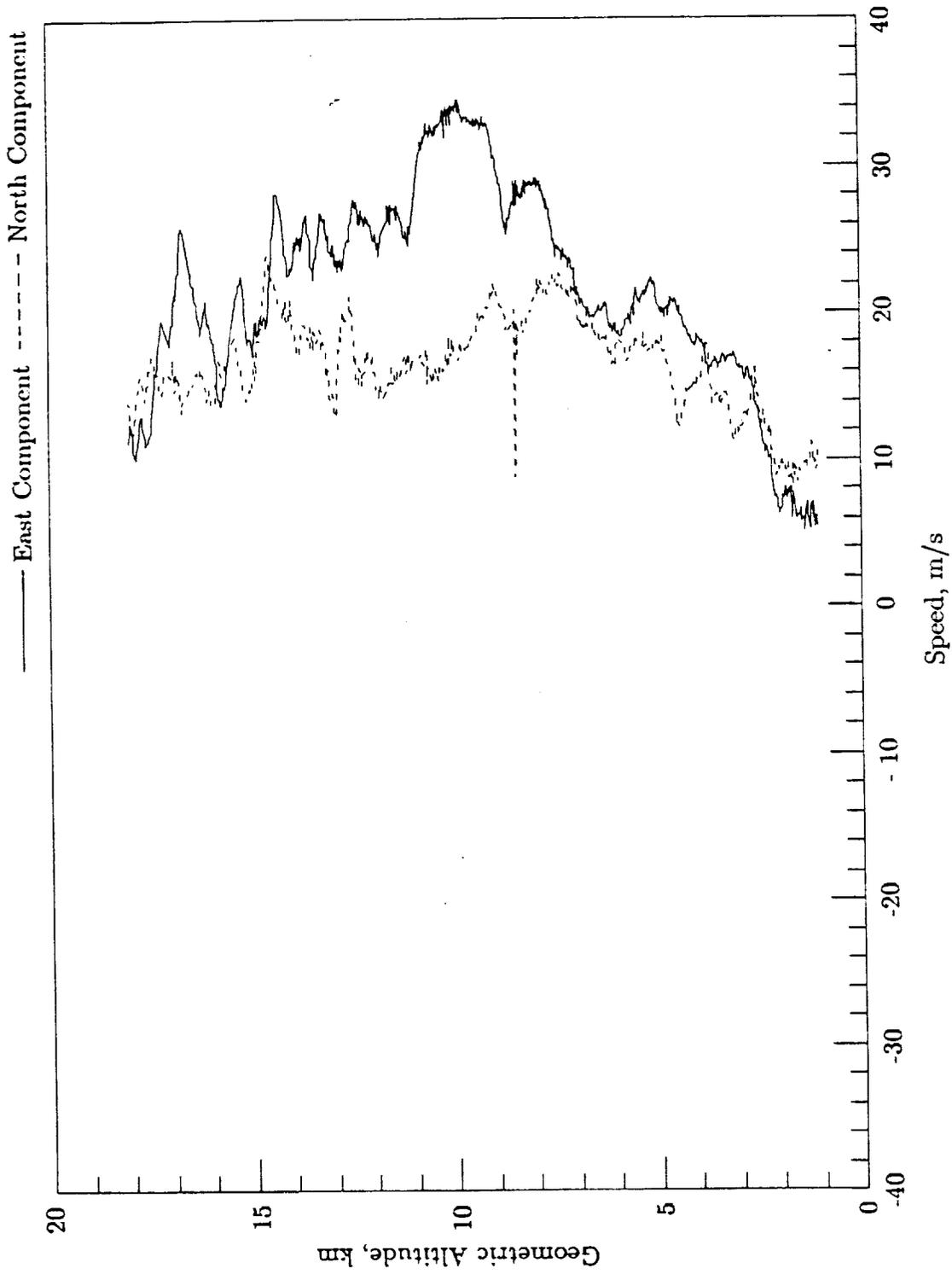


Figure 3.11 Wind velocity horizontal components from Jimsphere  
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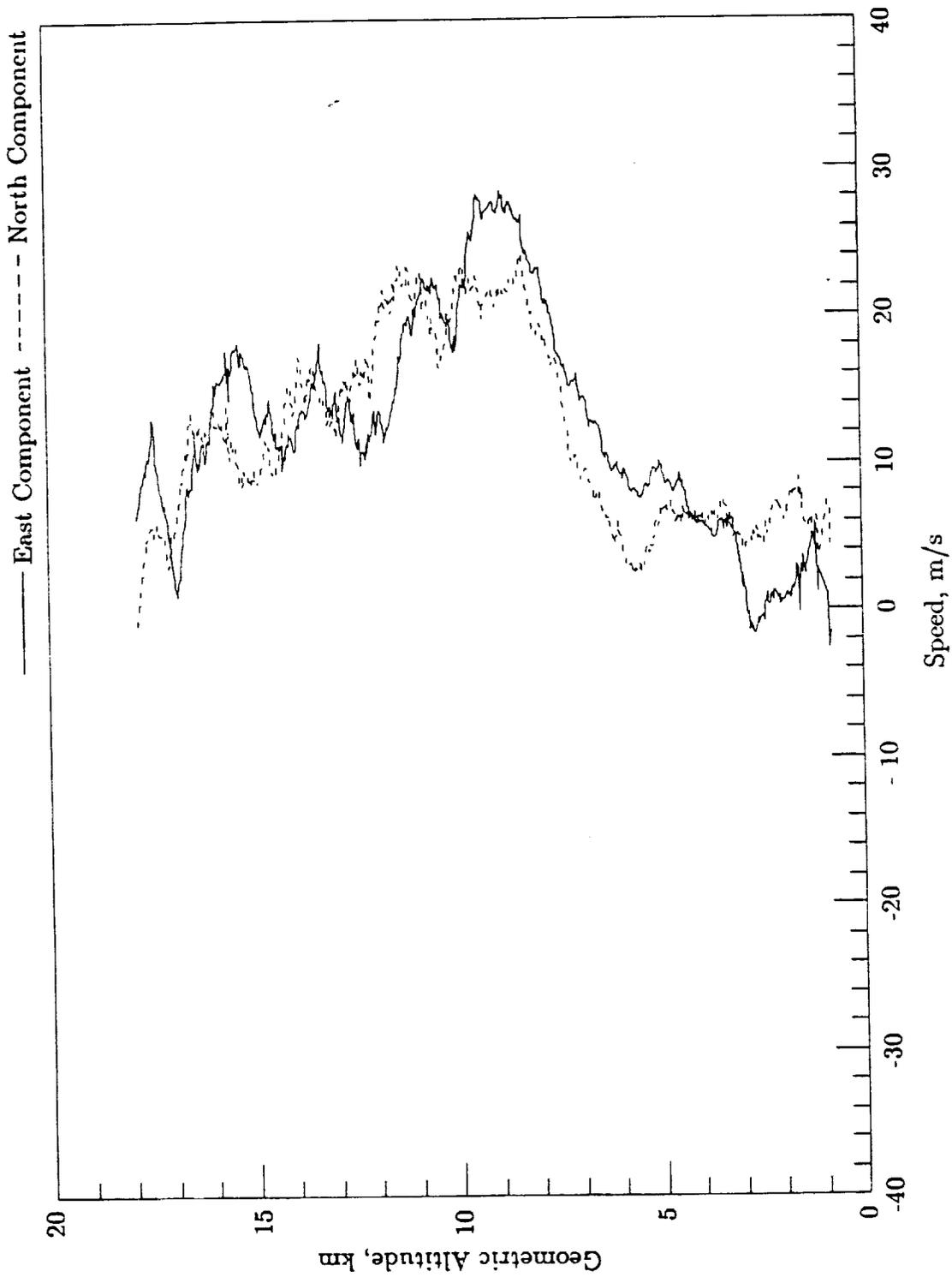


Figure 3.12 Wind velocity horizontal components from Jimsphere Release # 1, 25-Apr-89, Dryden Flight Research Facility.

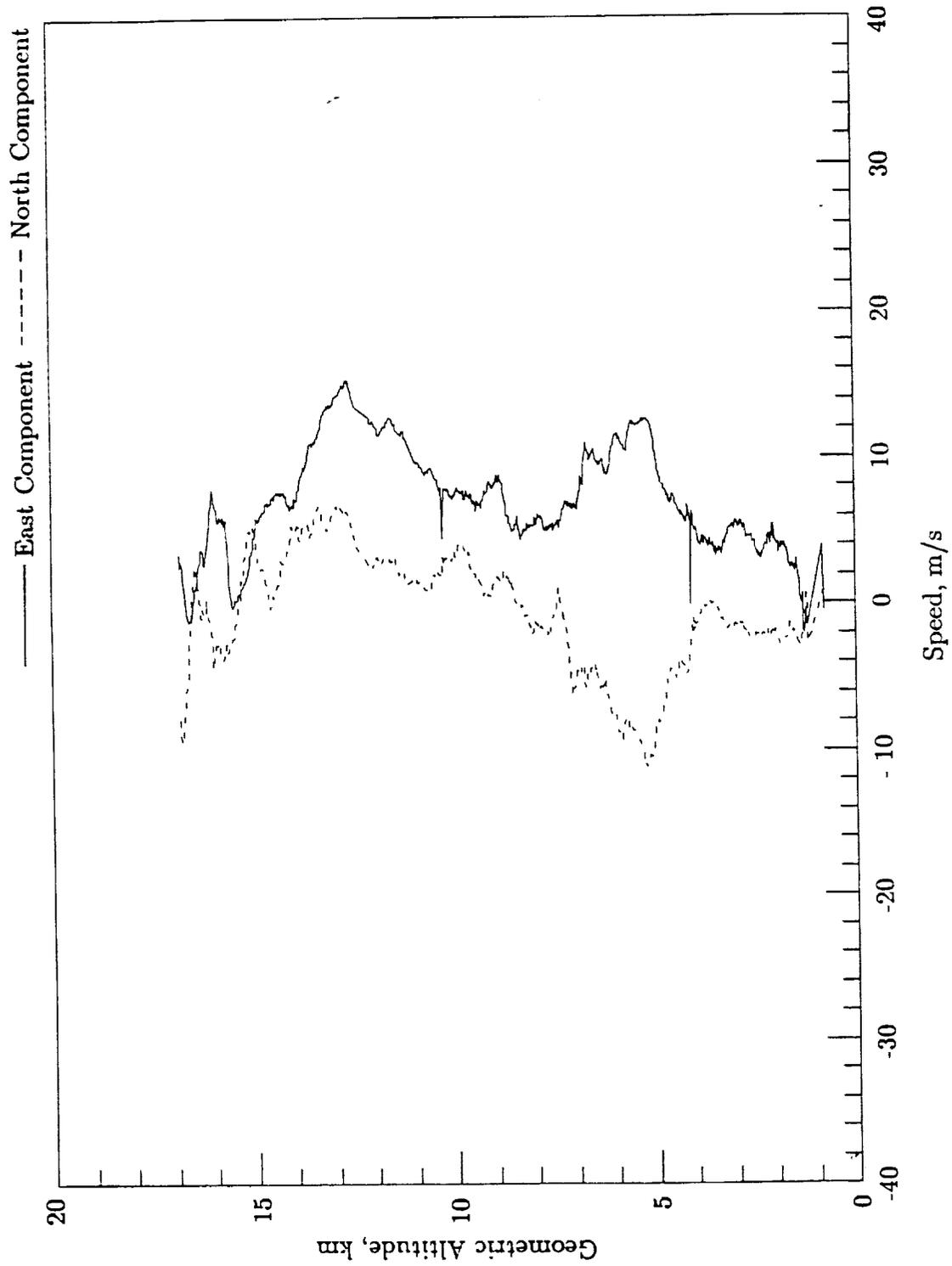


Figure 3.13 Wind velocity horizontal components from Jimsphere Release # 1, 20-Jul-89, Dryden Flight Research Facility.

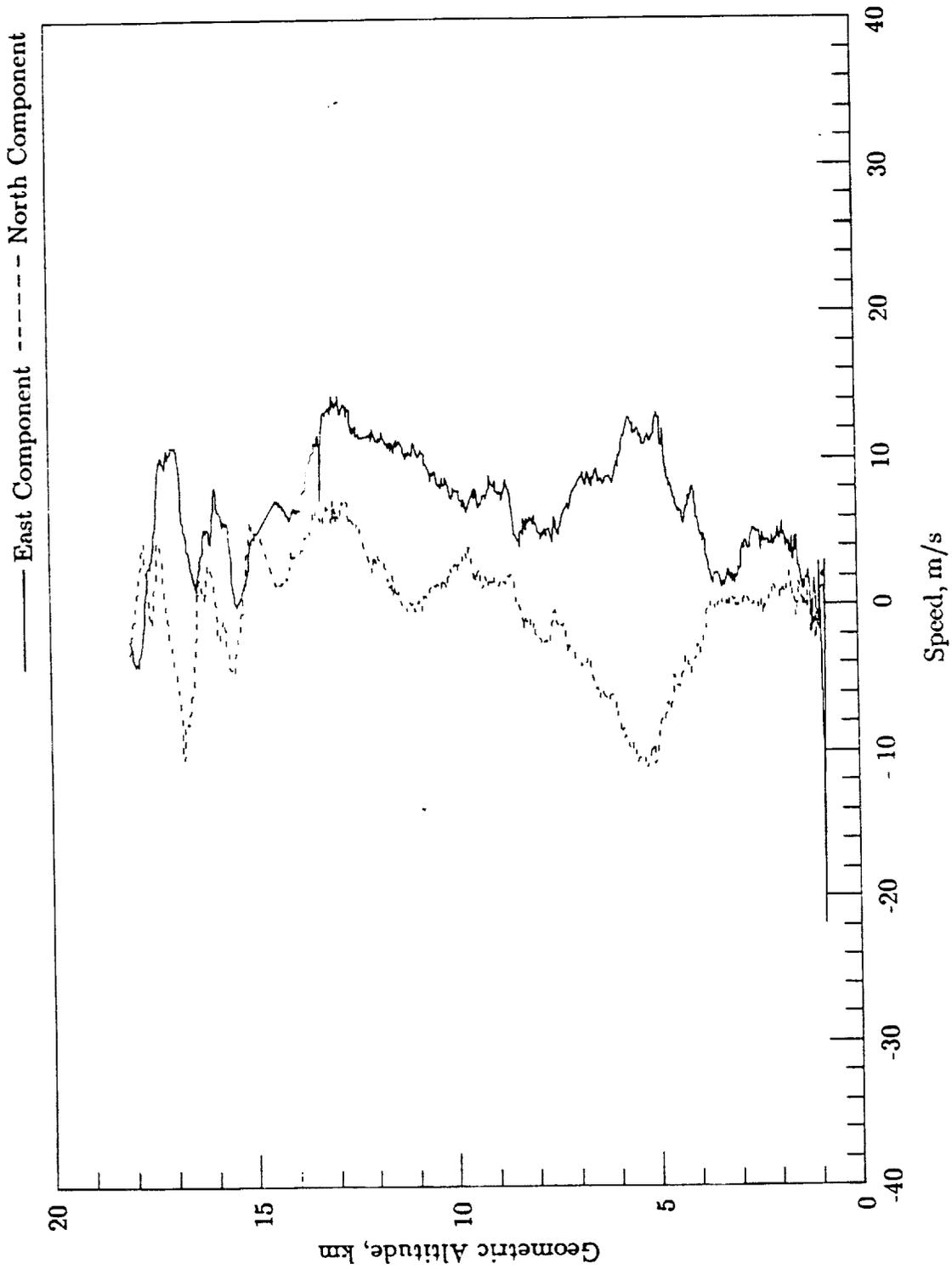


Figure 3.14 Wind velocity horizontal components from Jimsphere Release # 2, 20-Jul-89, Dryden Flight Research Facility.

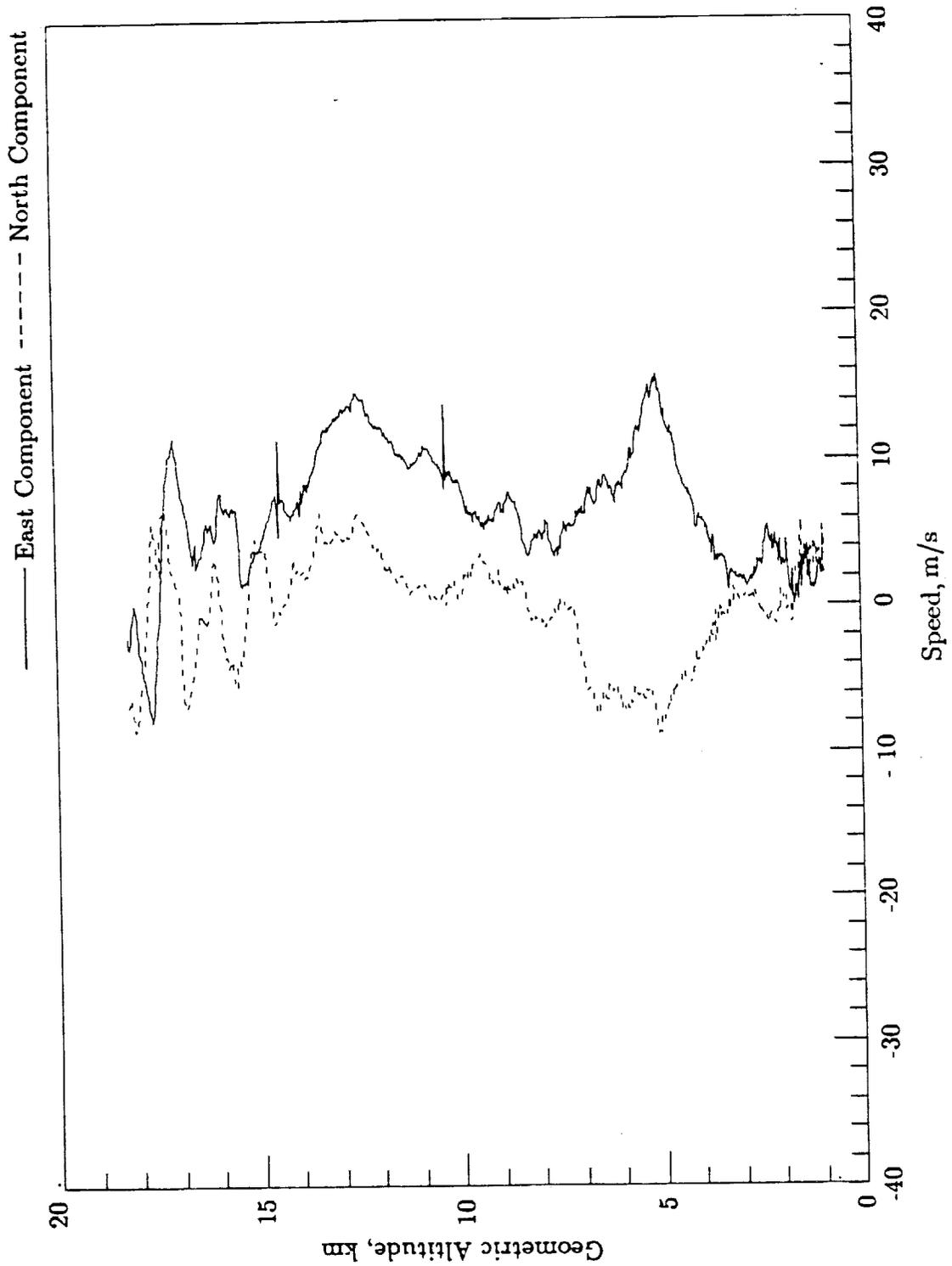


Figure 3.15 Wind velocity horizontal components from Jimsphere Release # 3, 20-Jul-89, Dryden Flight Research Facility.

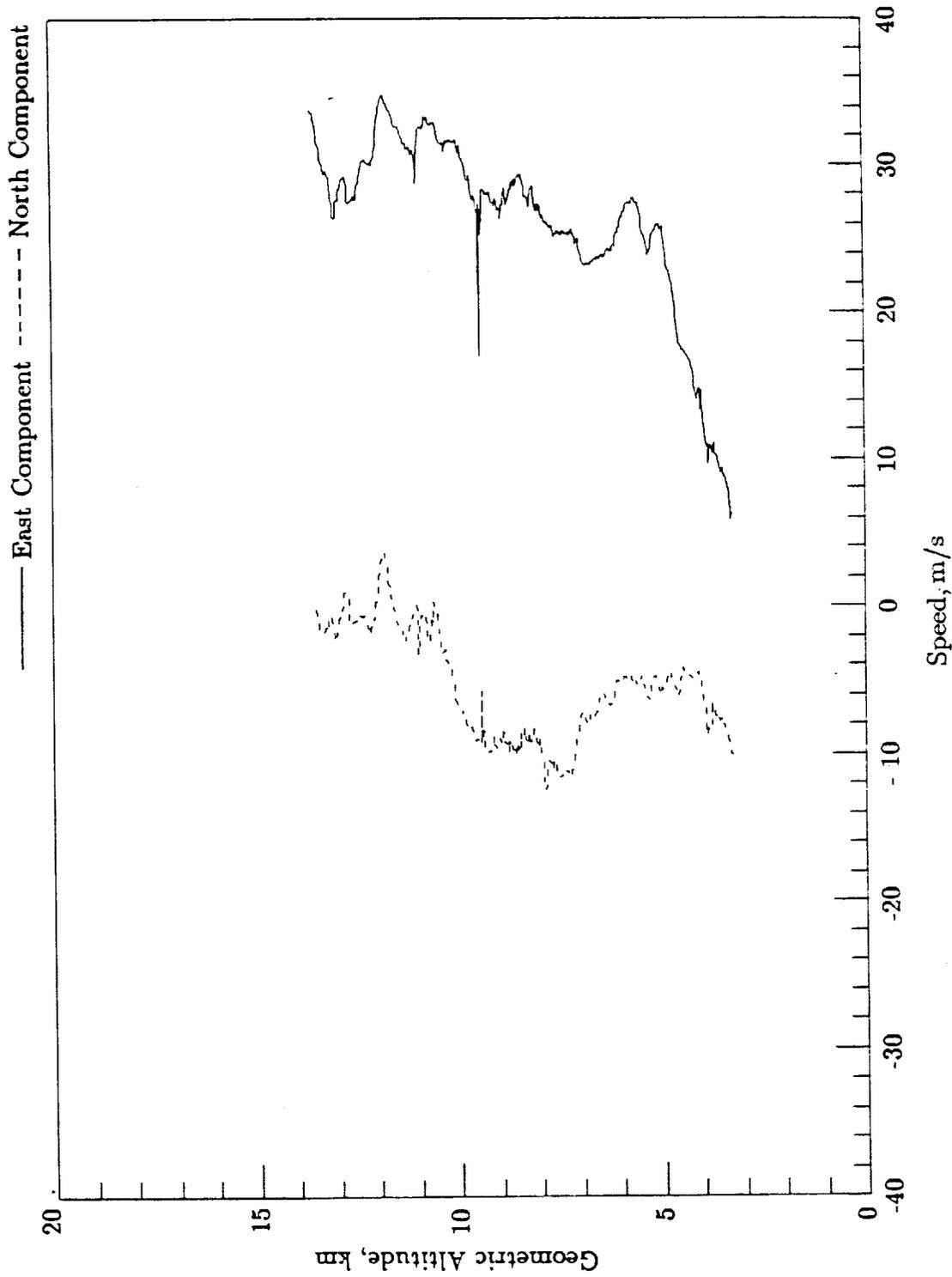


Figure 3.16 Wind velocity horizontal components from F-104 data, Climb # 1, 22-Jun-88, Dryden Flight Research Facility, INS ground speed.

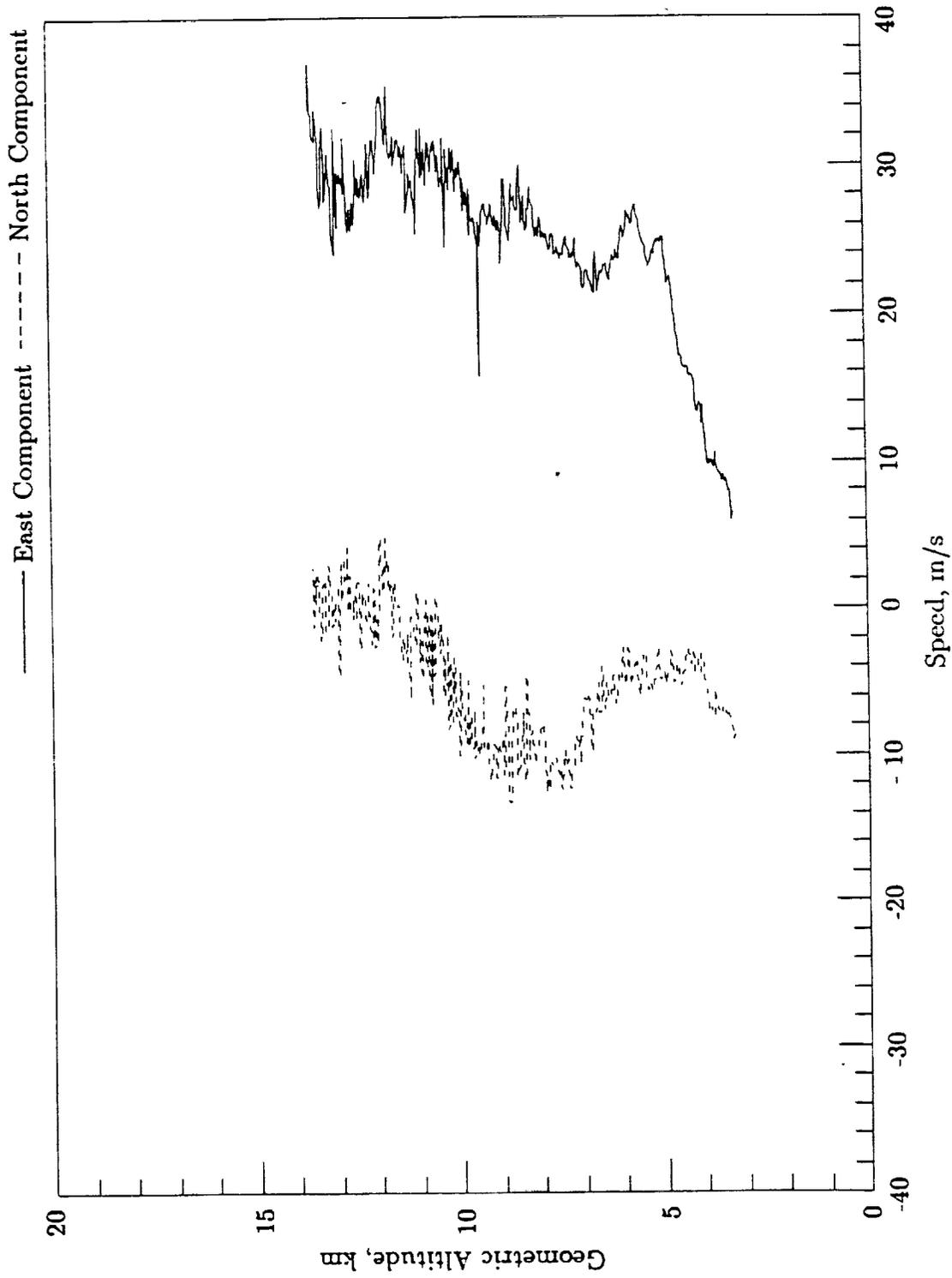


Figure 3.17 Wind velocity horizontal components from F-104 data, Climb # 1, 22-Jun-88, Dryden Flight Research Facility, radar ground speed.

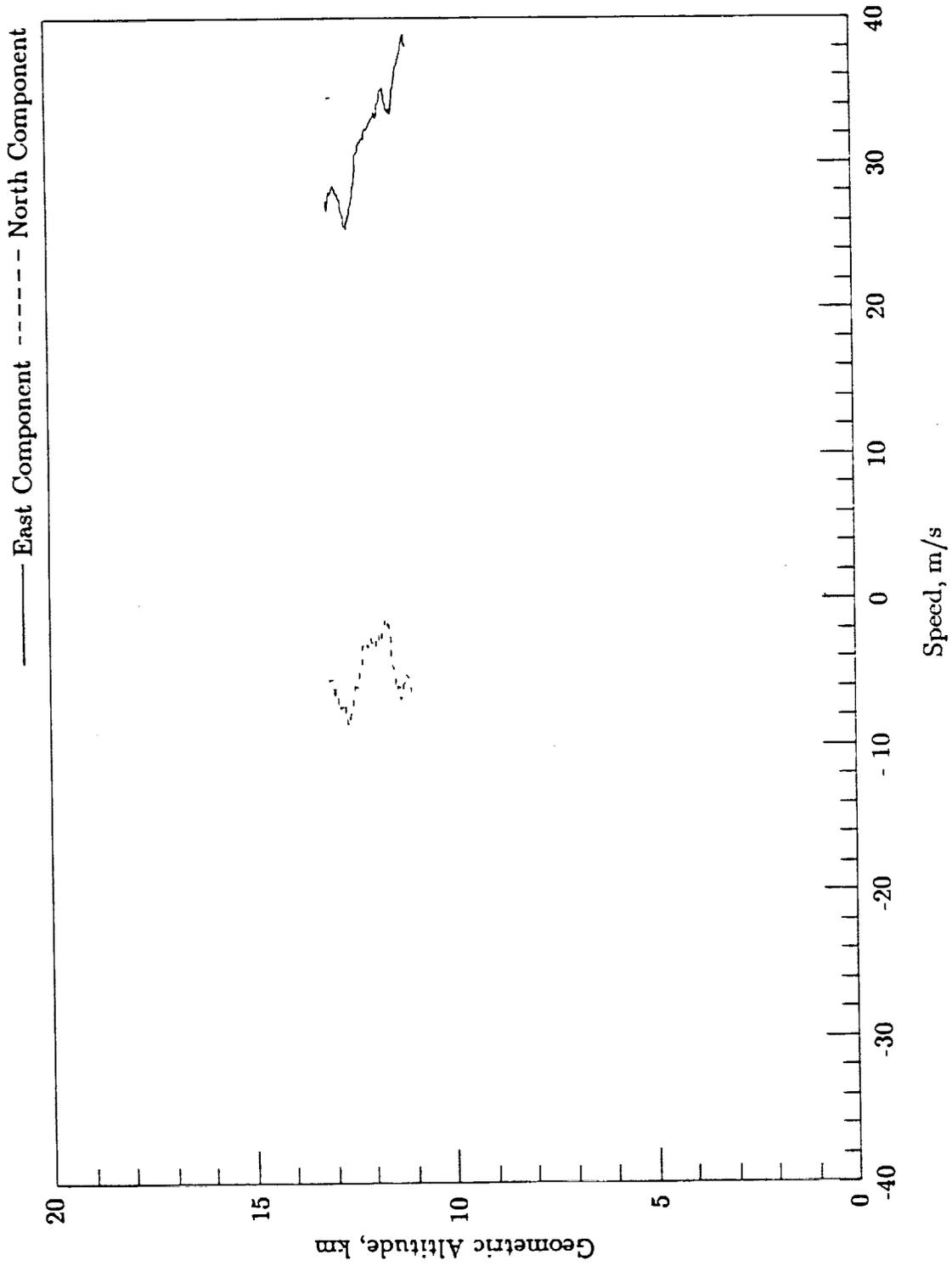


Figure 3.18 Wind velocity horizontal components from F-104 data, Climb # 2, 01-Aug-88, Dryden Flight Research Facility, INS ground speed.

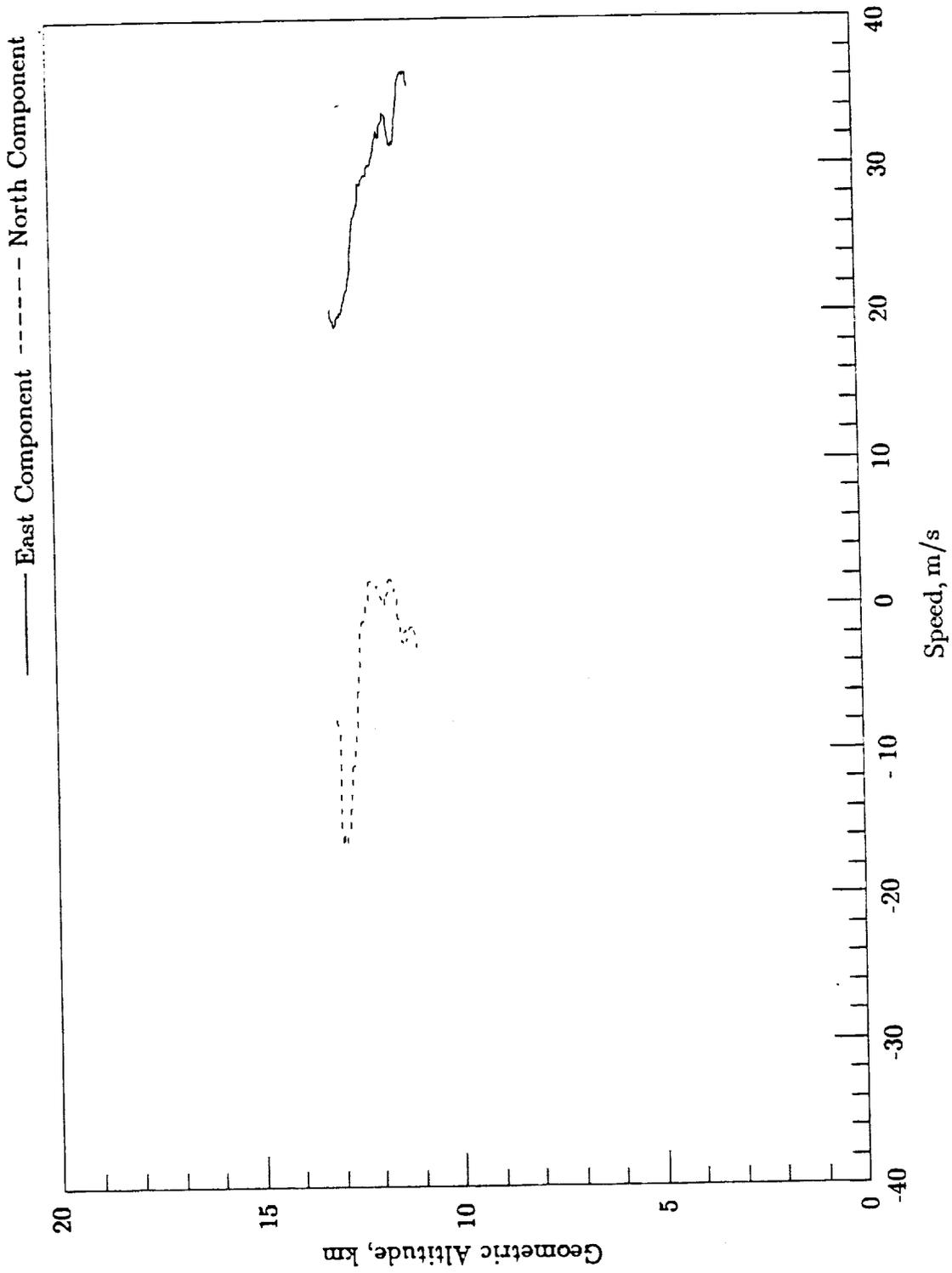


Figure 3.19 Wind velocity horizontal components from F-104 data, Climb # 2, 01-Aug-88, Dryden Flight Research Facility, radar ground speed.

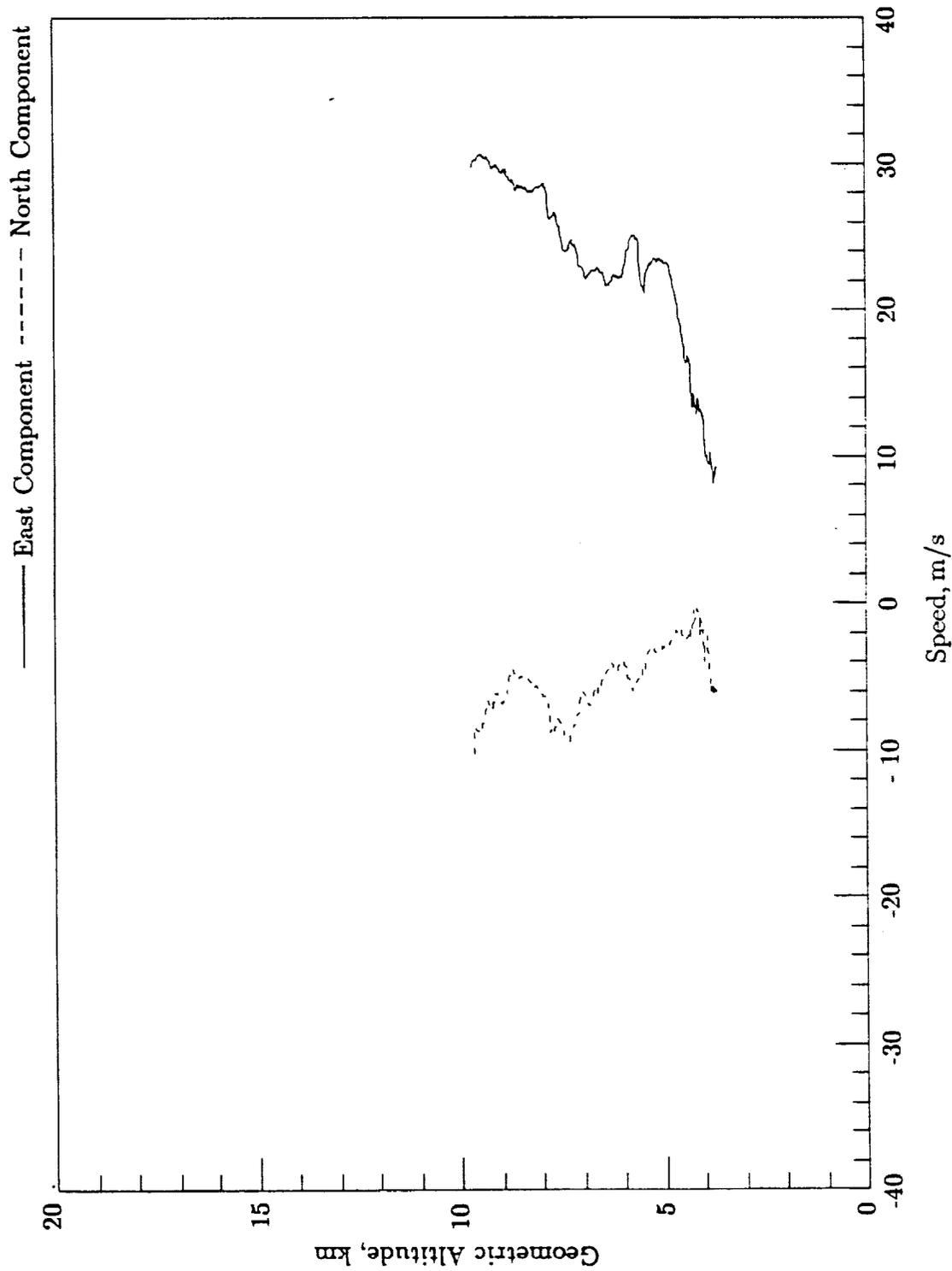


Figure 3.20 Wind velocity horizontal components from F-104 data, Descent # 1, 22-Jun-88, Dryden Flight Research Facility, INS ground speed.

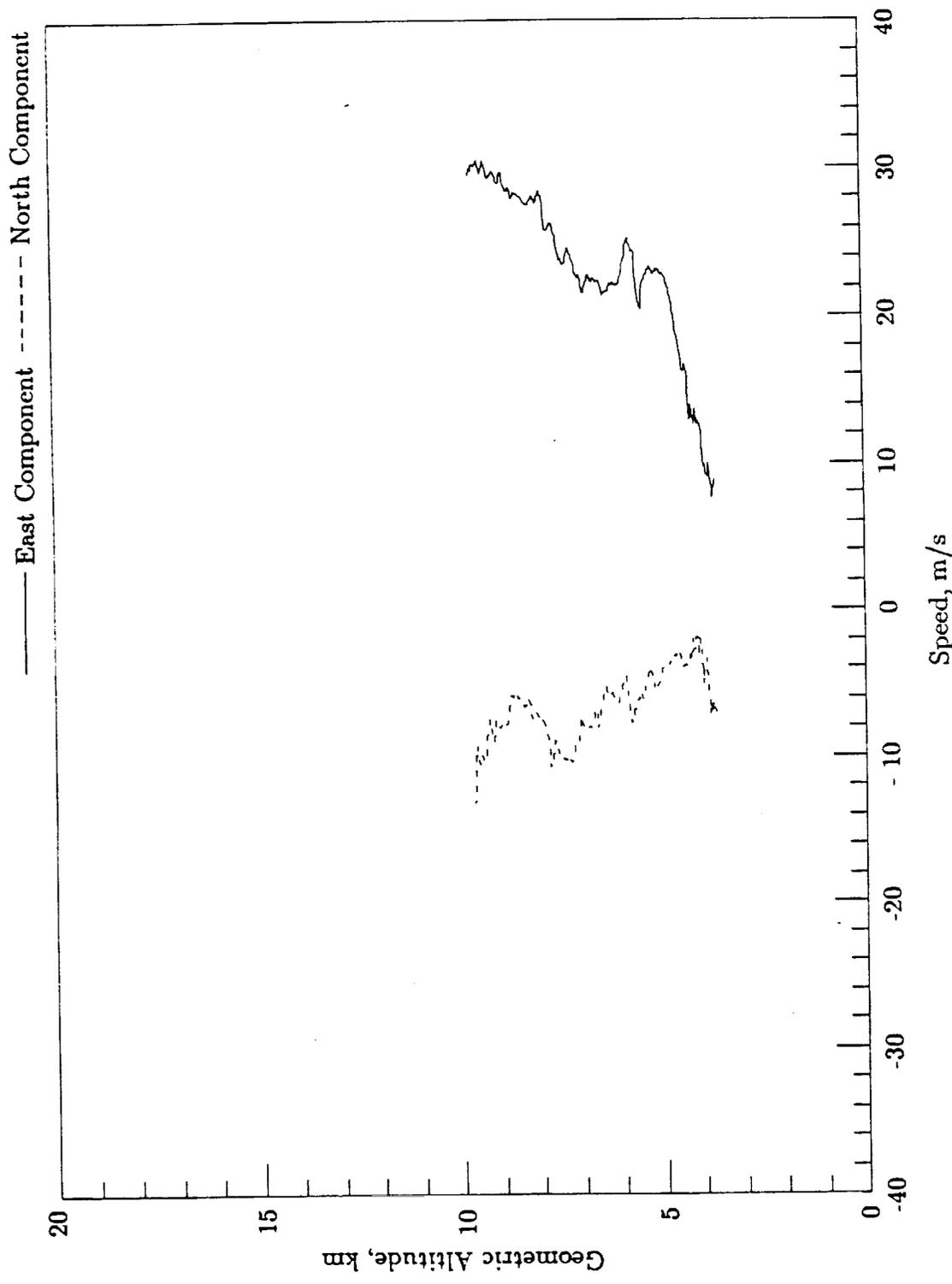


Figure 3.21 Wind velocity horizontal components from F-104 data, Descent # 1, 22-Jun-88, Dryden Flight Research Facility, radar ground speed.

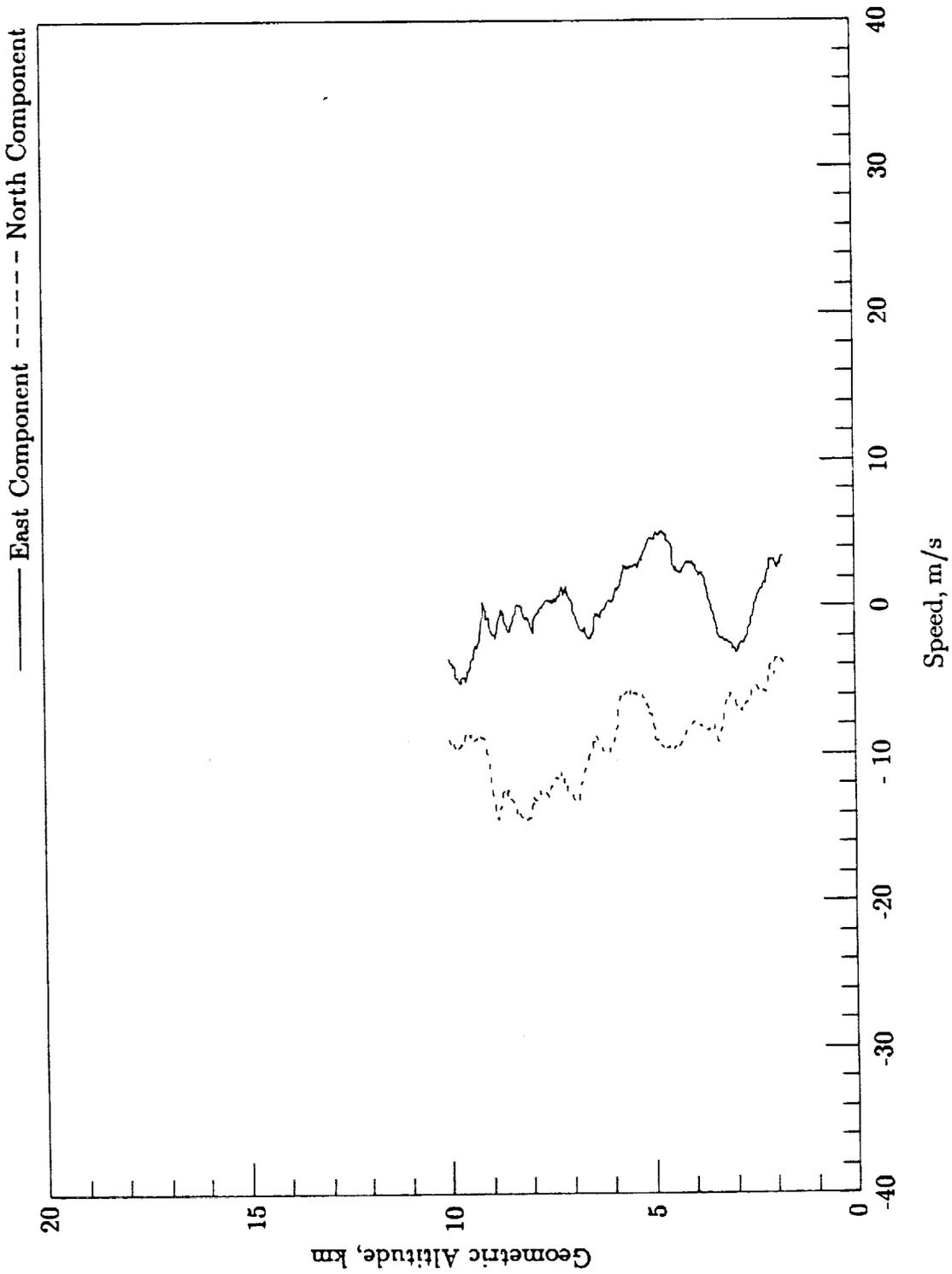


Figure 3.22 Wind velocity horizontal components from F-104 data, Climb # 1, 20-Jul-88, Dryden Flight Research Facility, INS ground speed.

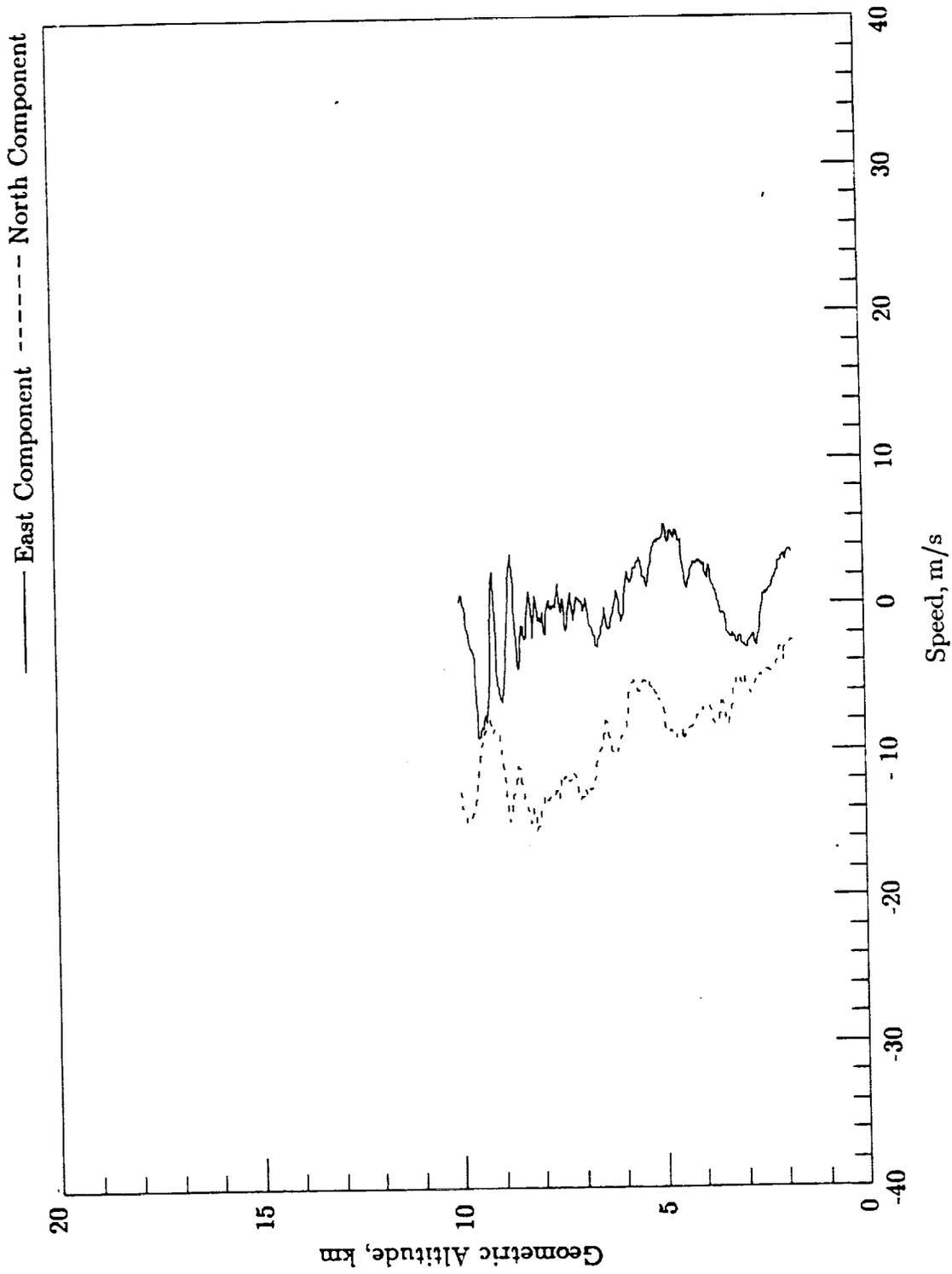


Figure 3.23 Wind velocity horizontal components from F-104 data, Climb # 1, 20-Jul-88, Dryden Flight Research Facility, radar ground speed.

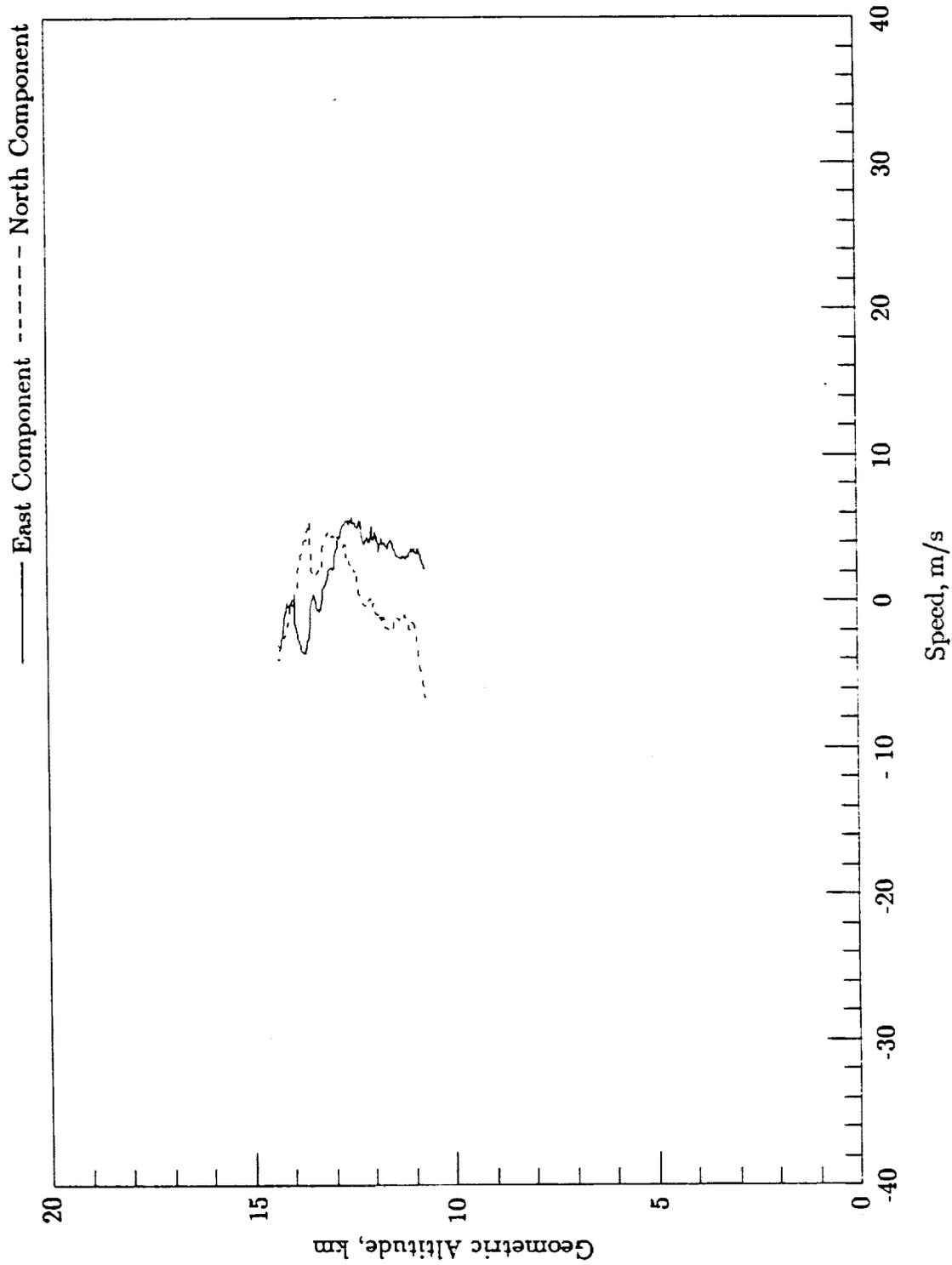


Figure 3.24 Wind velocity horizontal components from F-104 data, Climb # 2, 20-Jul-88, Dryden Flight Research Facility, INS ground speed.

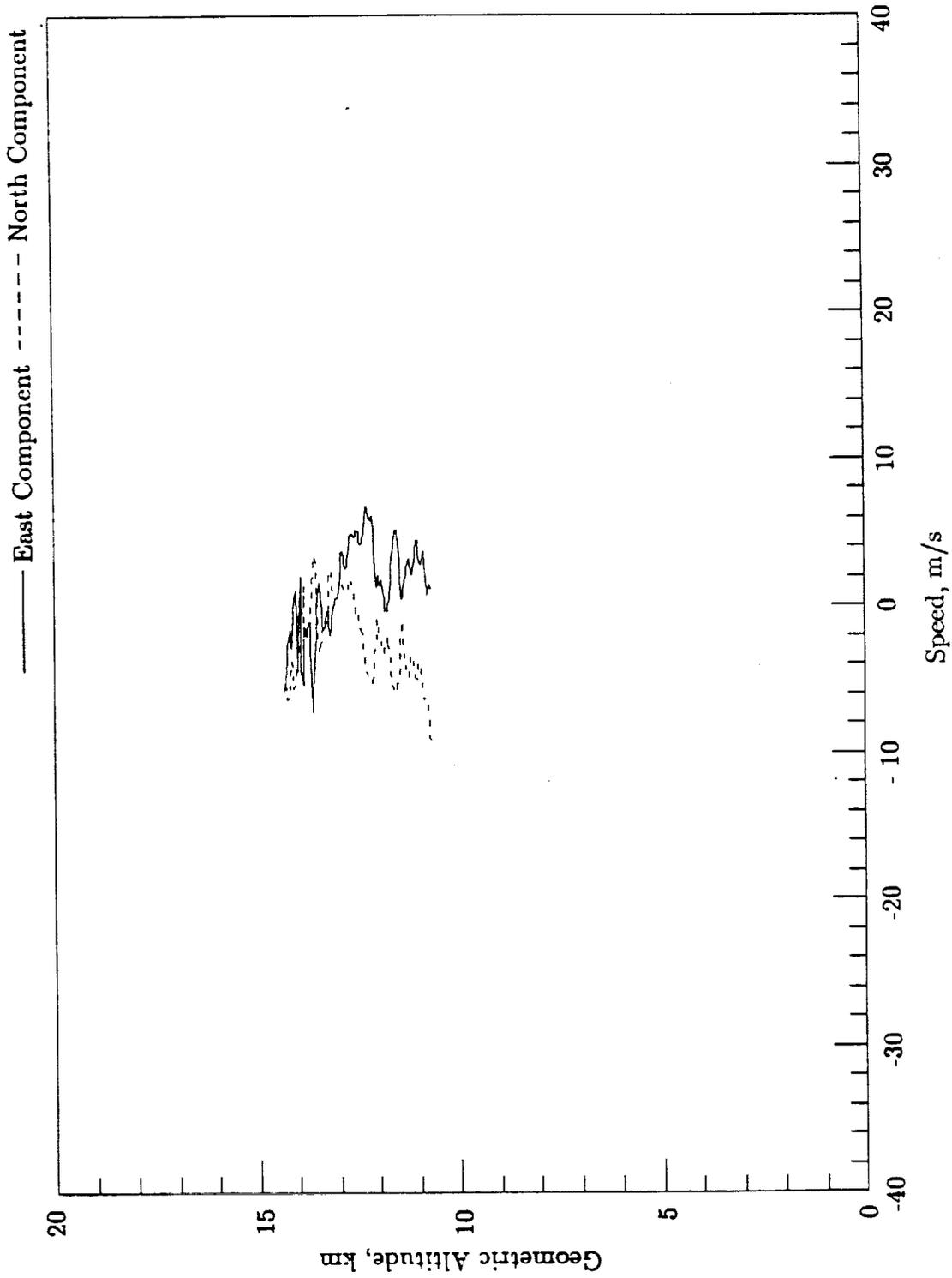


Figure 3.25 Wind velocity horizontal components from F-104 data, Climb # 2, 20-Jul-88, Dryden Flight Research Facility, radar ground speed.

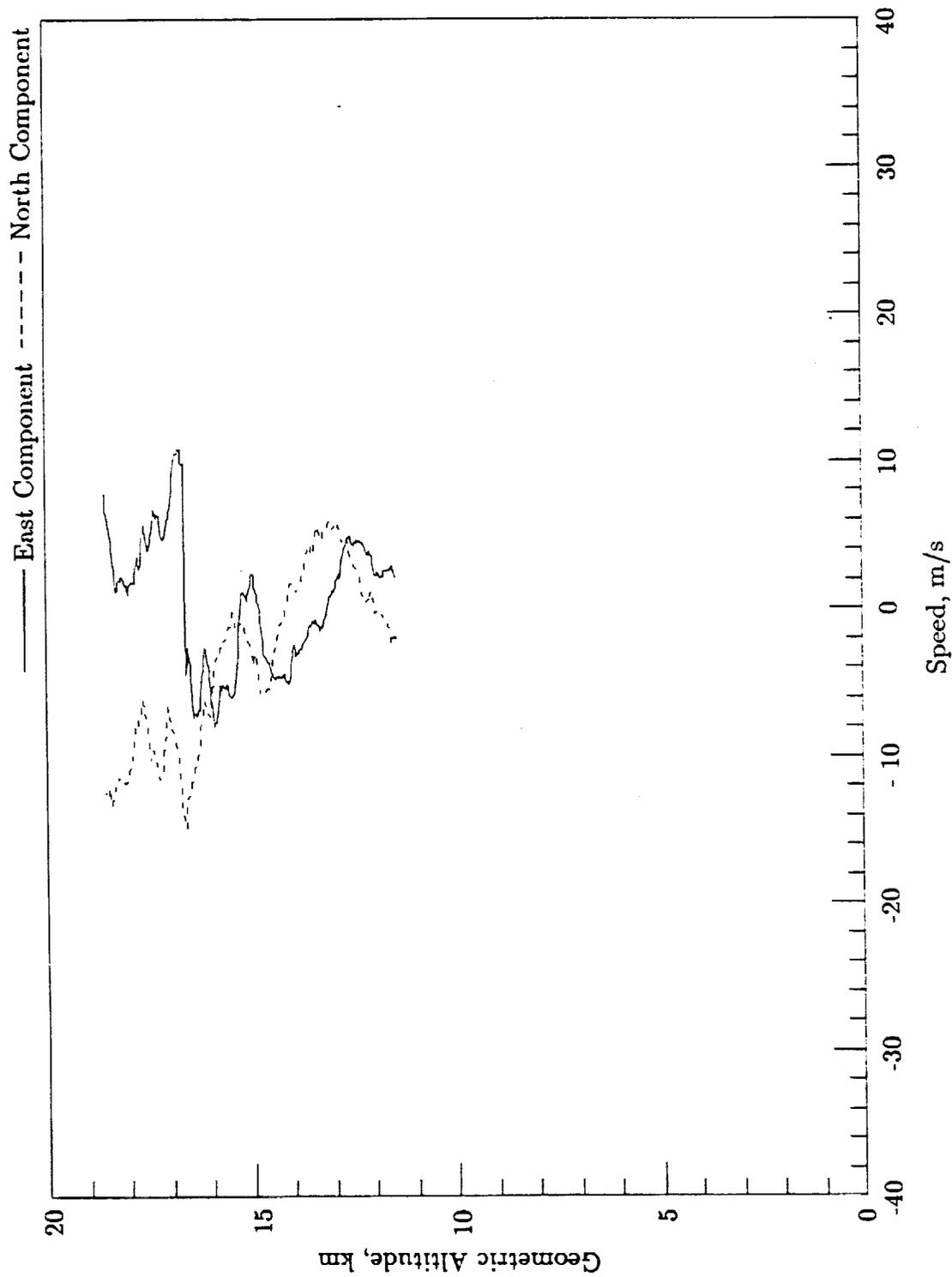
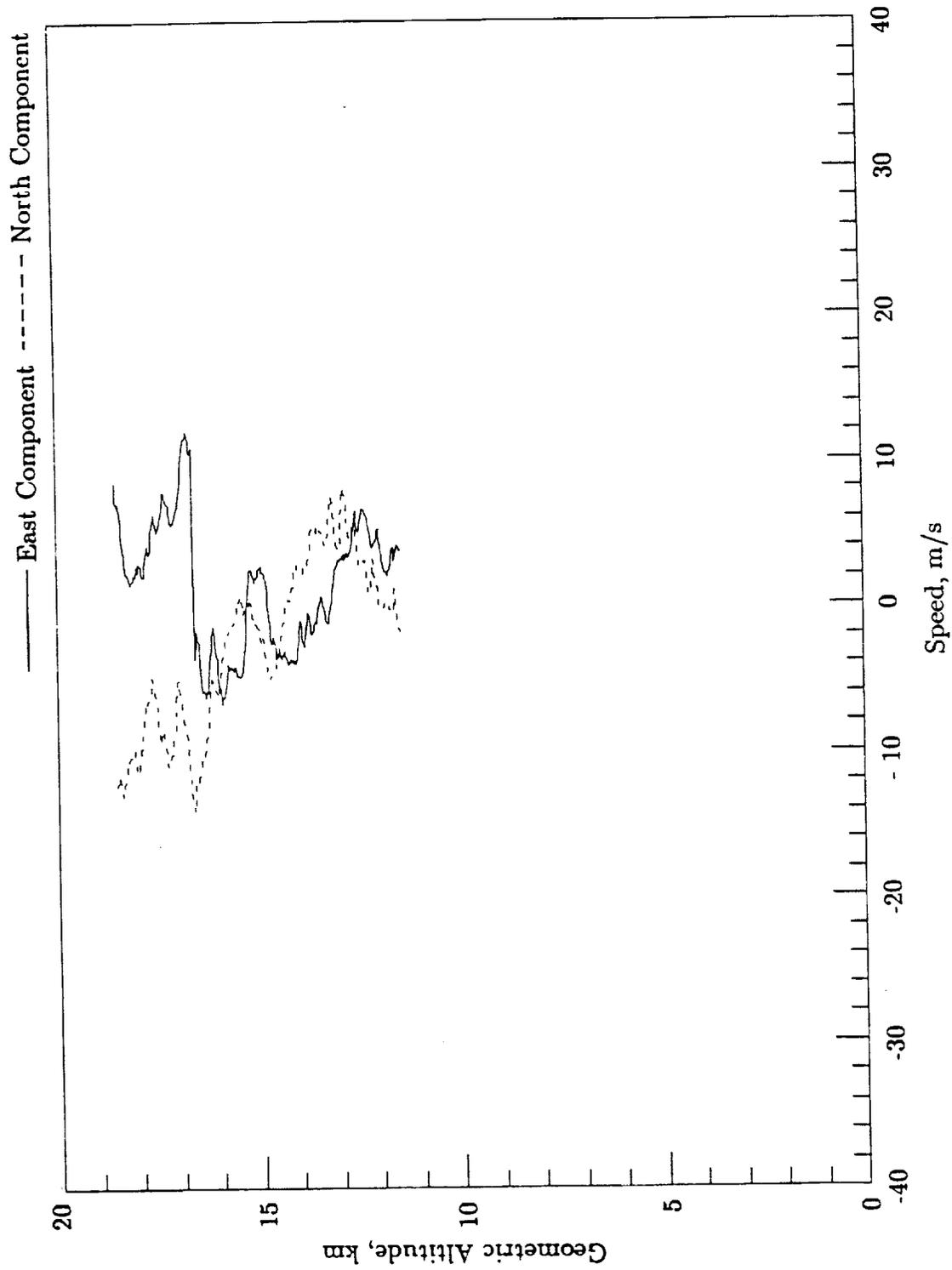
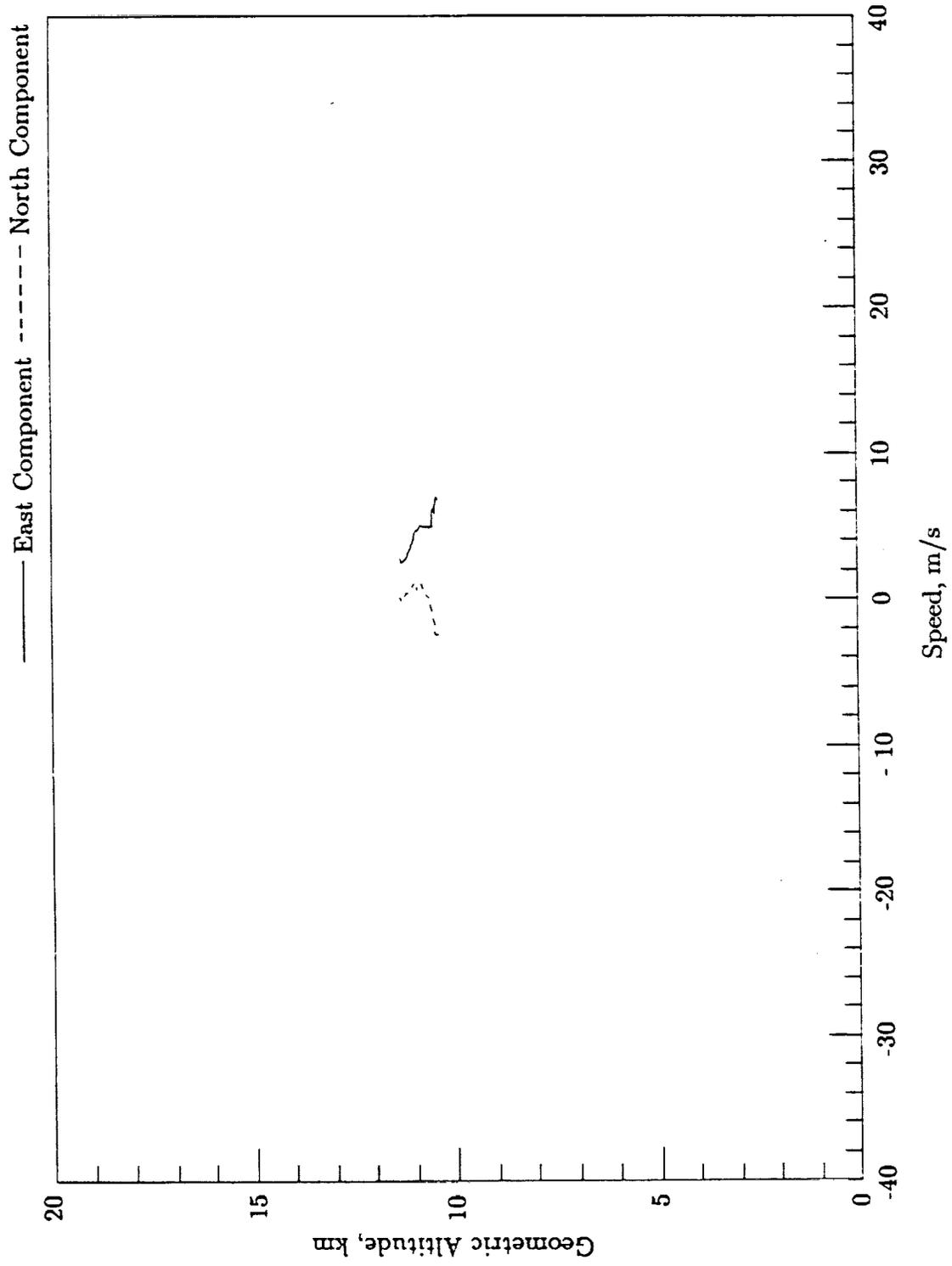


Figure 3.26 Wind velocity horizontal components from F-104 data, Climb # 3, 20-Jul-88, Dryden Flight Research Facility, INS ground speed.



**Figure 3.27** Wind velocity horizontal components from F-104 data, Climb # 3, 20-Jul-88, Dryden Flight Research Facility, radar ground speed.



**Figure 3.28** Wind velocity horizontal components from F-104 data, Descent # 1, 20-Jul-88, Dryden Flight Research Facility, INS ground speed.

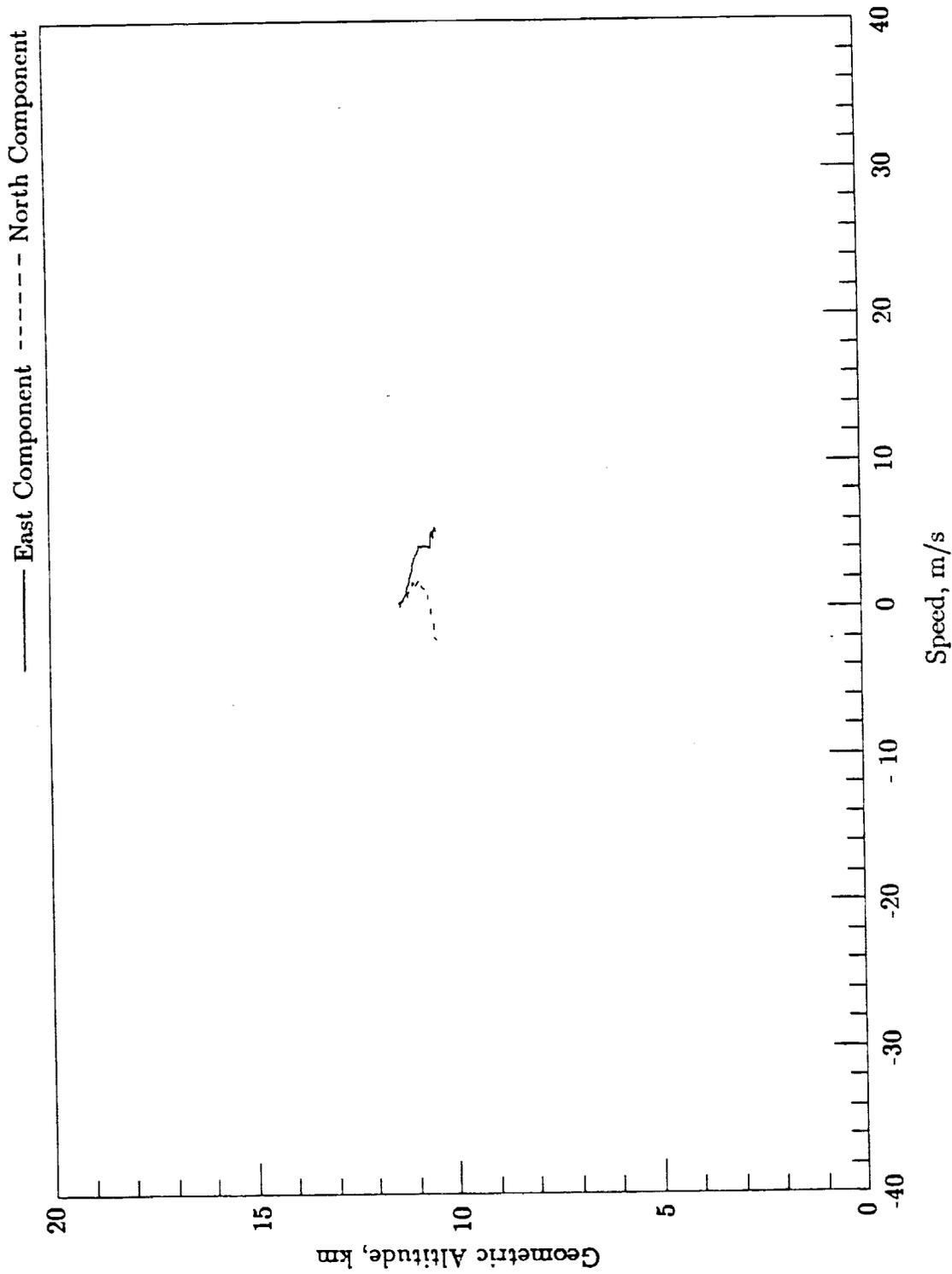
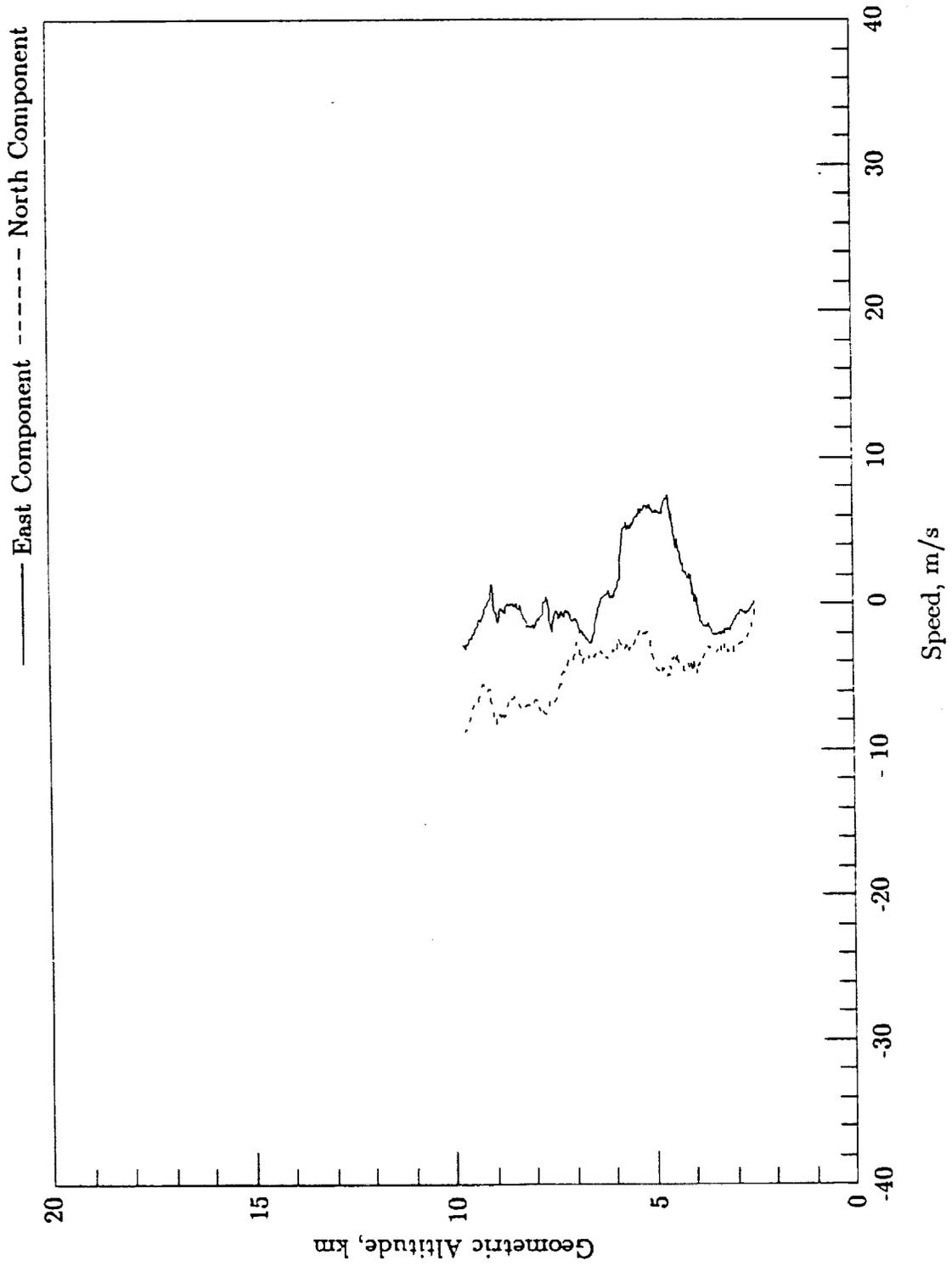


Figure 3.29 Wind velocity horizontal components from F-104 data, Descent # 1, 20-Jul-88, Dryden Flight Research Facility, radar ground speed.



**Figure 3.30** Wind velocity horizontal components from F-104 data, Descent # 2, 20-Jul-88, Dryden Flight Research Facility, INS ground speed.

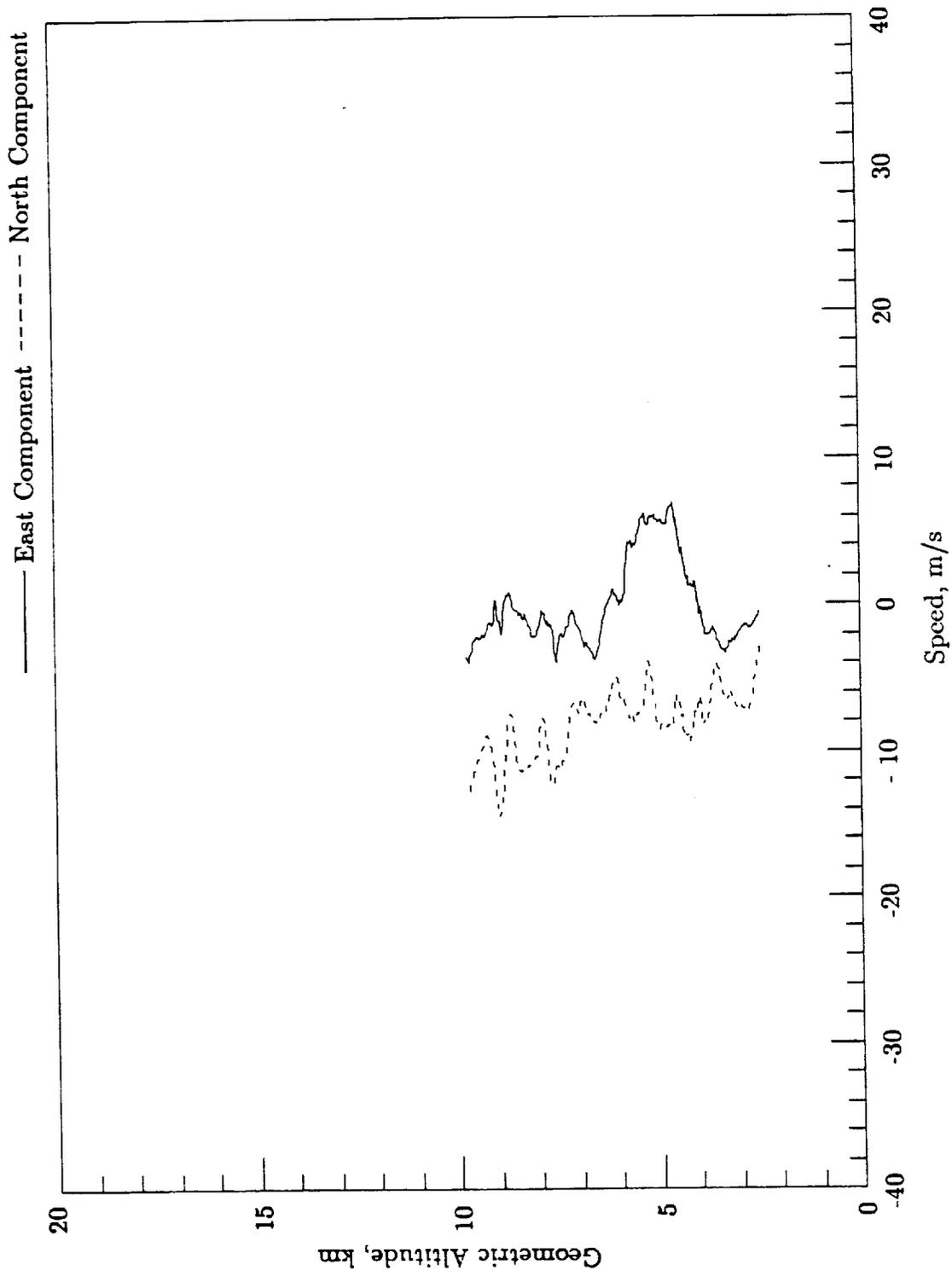


Figure 3.31 Wind velocity horizontal components from F-104 data, Descent # 2,20-Jul-88, Dryden Flight Research Facility, radar ground speed.

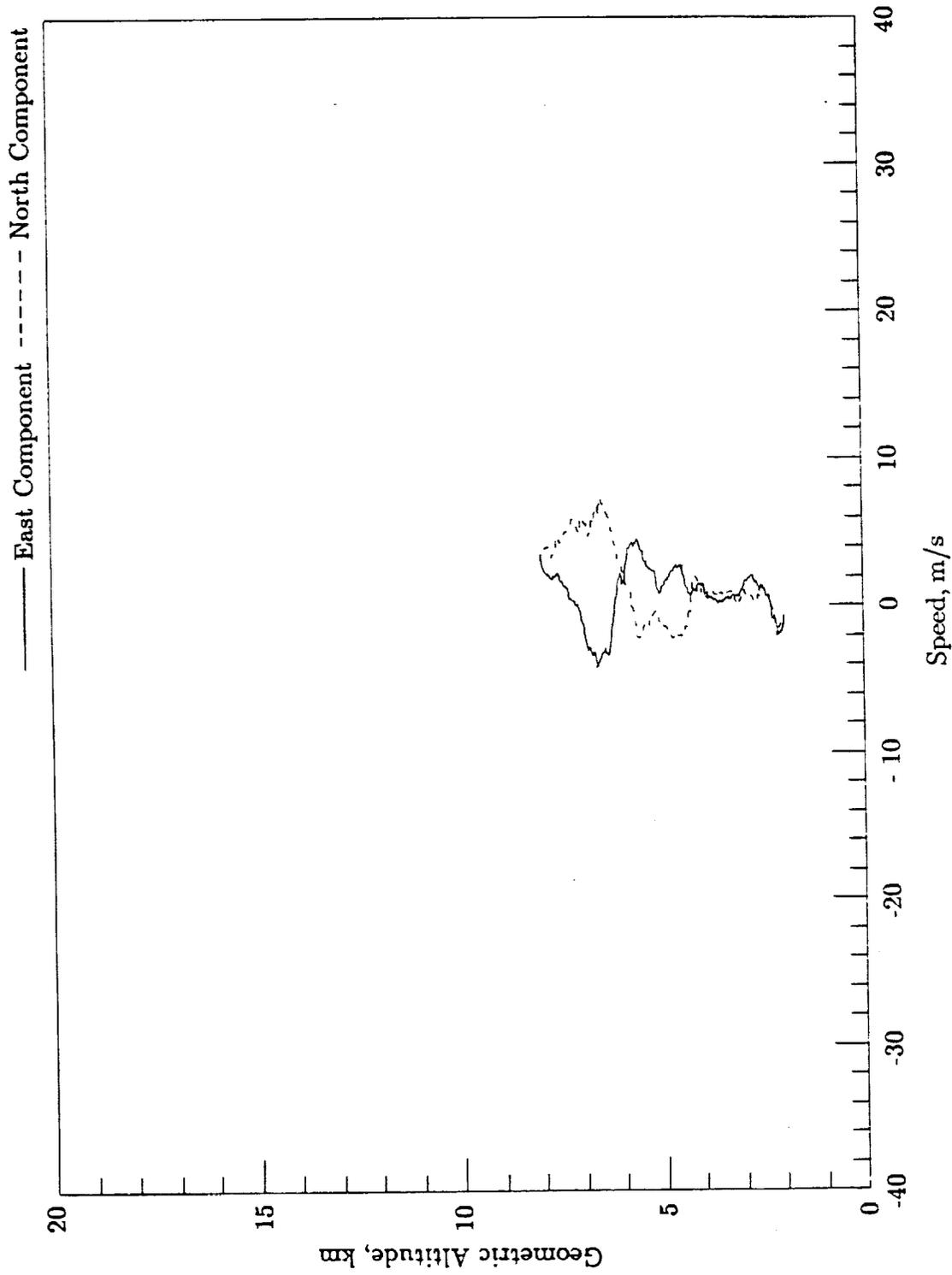
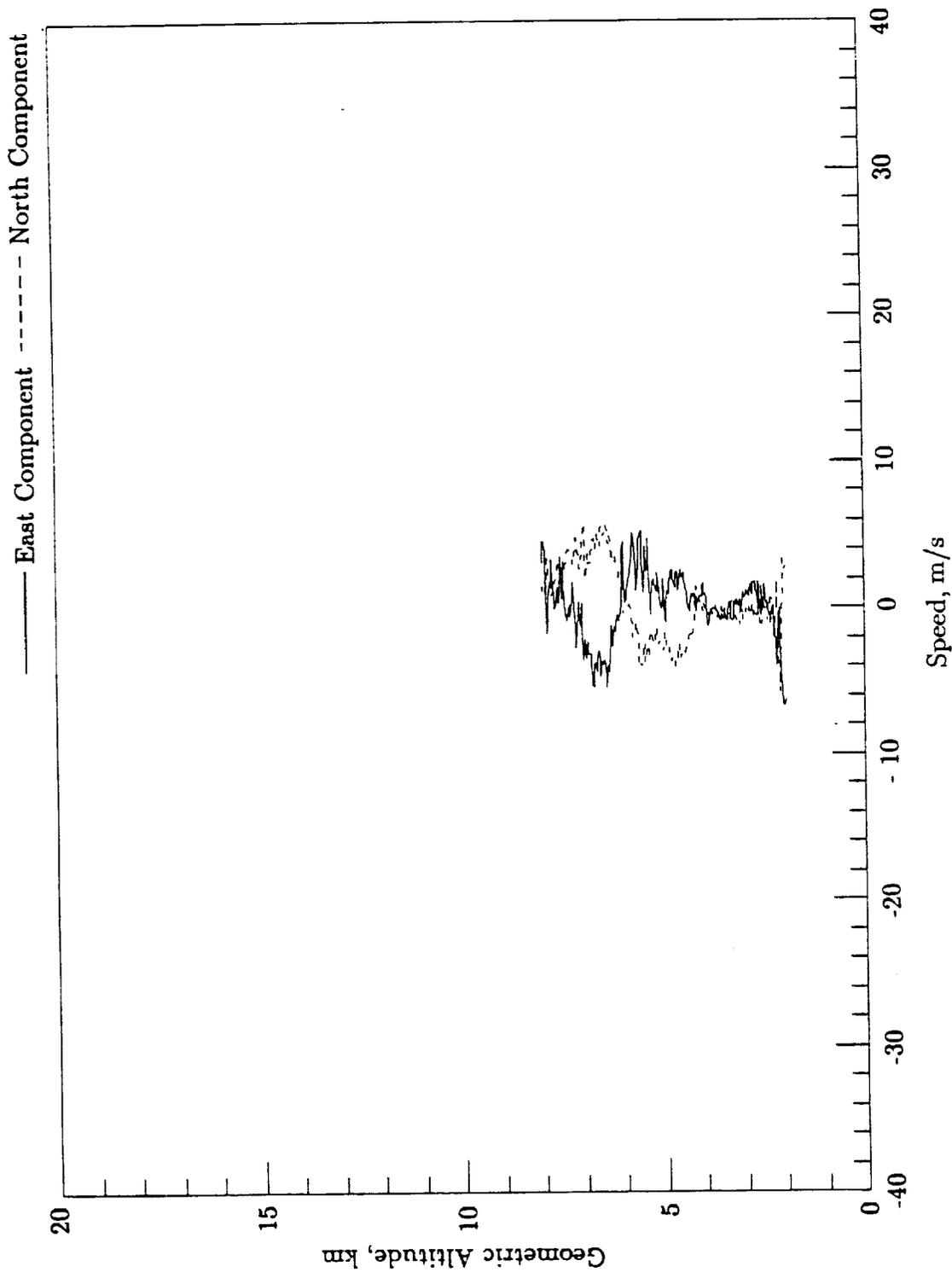


Figure 3.32 Wind velocity horizontal components from F-104 data, Climb # 1, 01-Aug-88, Dryden Flight Research Facility, INS ground speed.



**Figure 3.33** Wind velocity horizontal components from F-104 data, Climb # 1, 01-Aug-88, Dryden Flight Research Facility, radar ground speed.

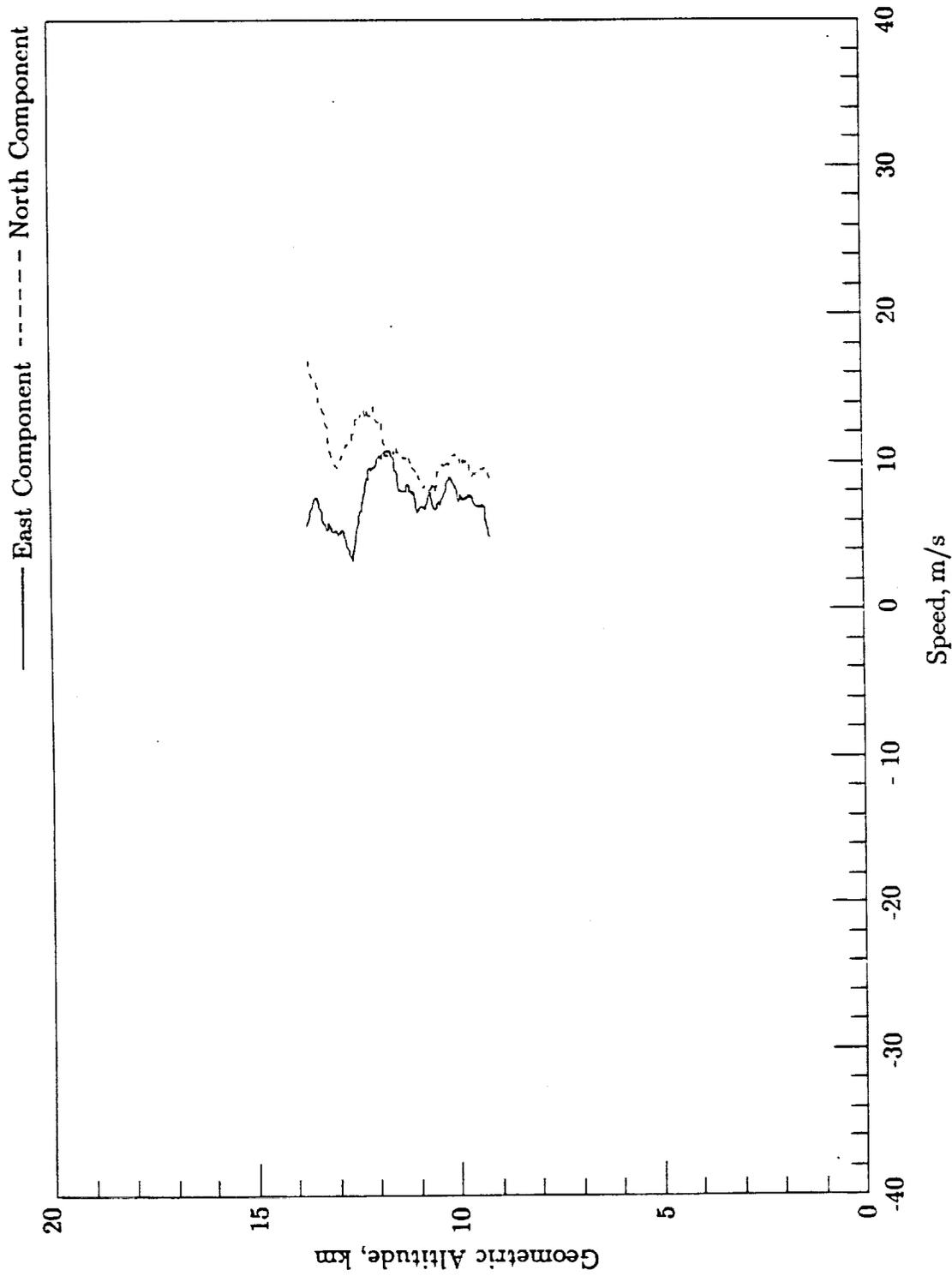


Figure 3.34 Wind velocity horizontal components from F-104 data, Climb # 2, 01-Aug-88, Dryden Flight Research Facility, INS ground speed.

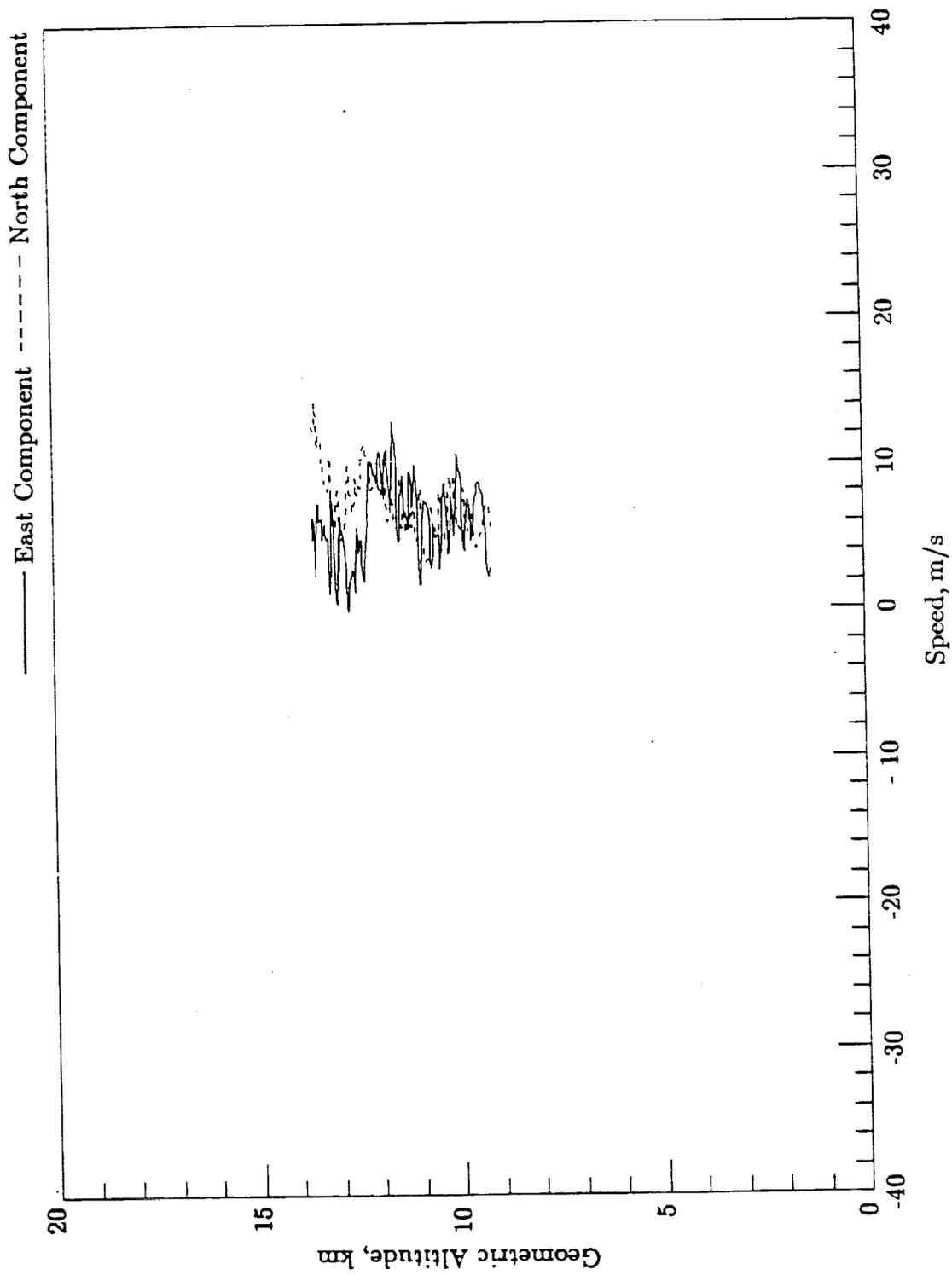
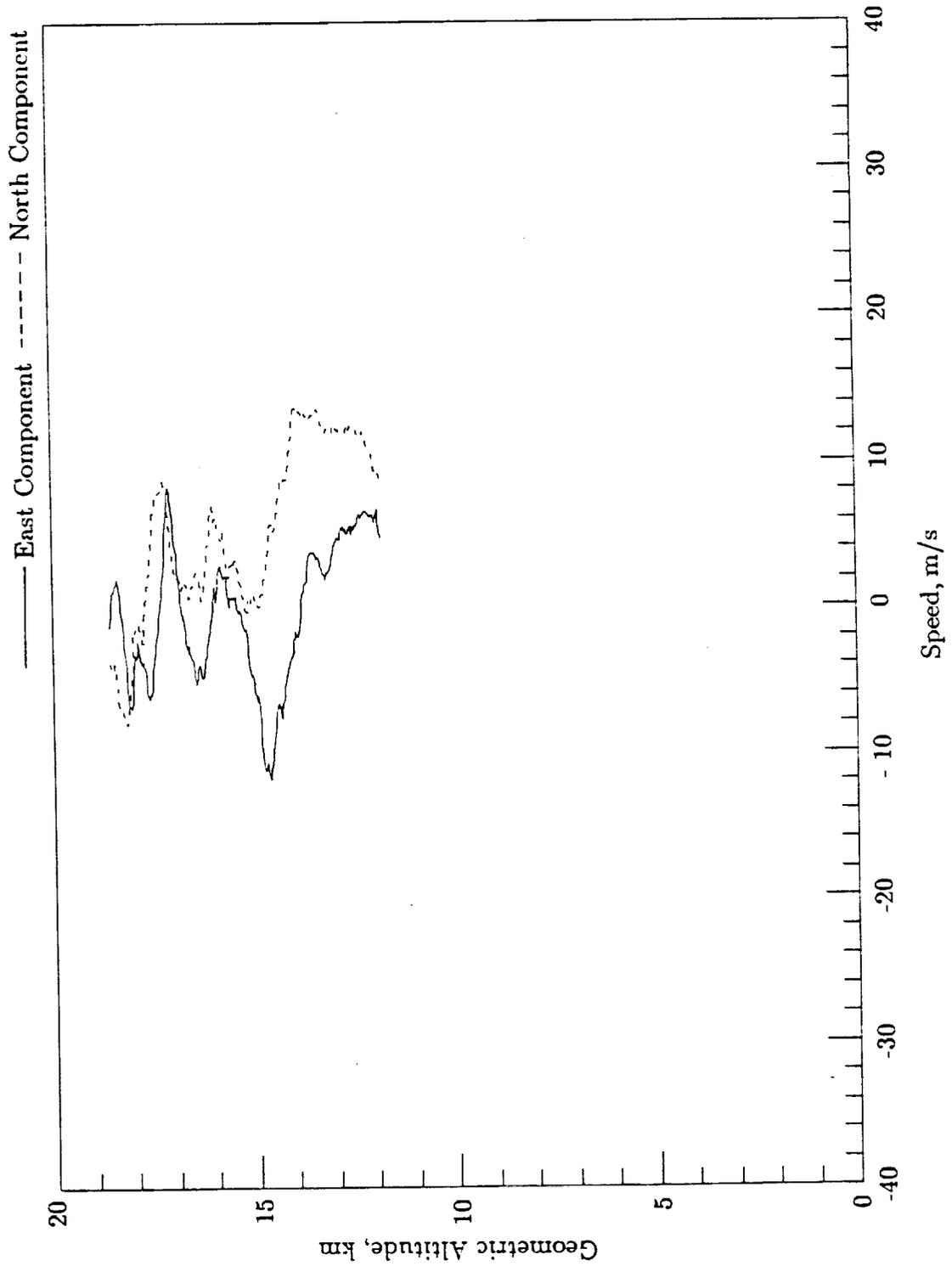


Figure 3.35 Wind velocity horizontal components from F-104 data, Climb # 2, 01-Aug-88, Dryden Flight Research Facility, radar ground speed.



**Figure 3.36** Wind velocity horizontal components from F-104 data, Climb # 3, 01-Aug-88, Dryden Flight Research Facility, INS ground speed.

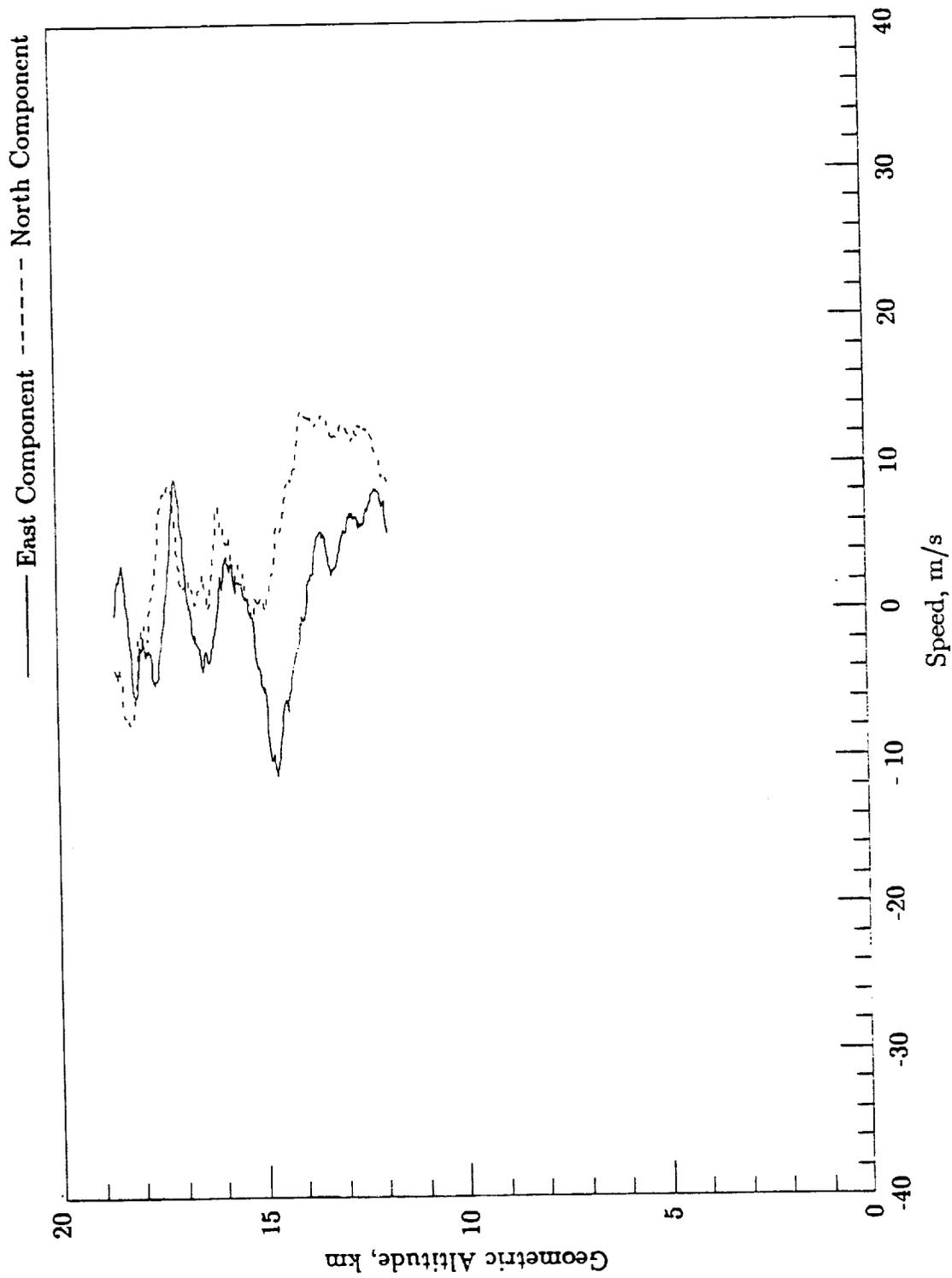


Figure 3.37 Wind velocity horizontal components from F-104 data, Climb # 3, 01-Aug-88, Dryden Flight Research Facility, radar ground speed.

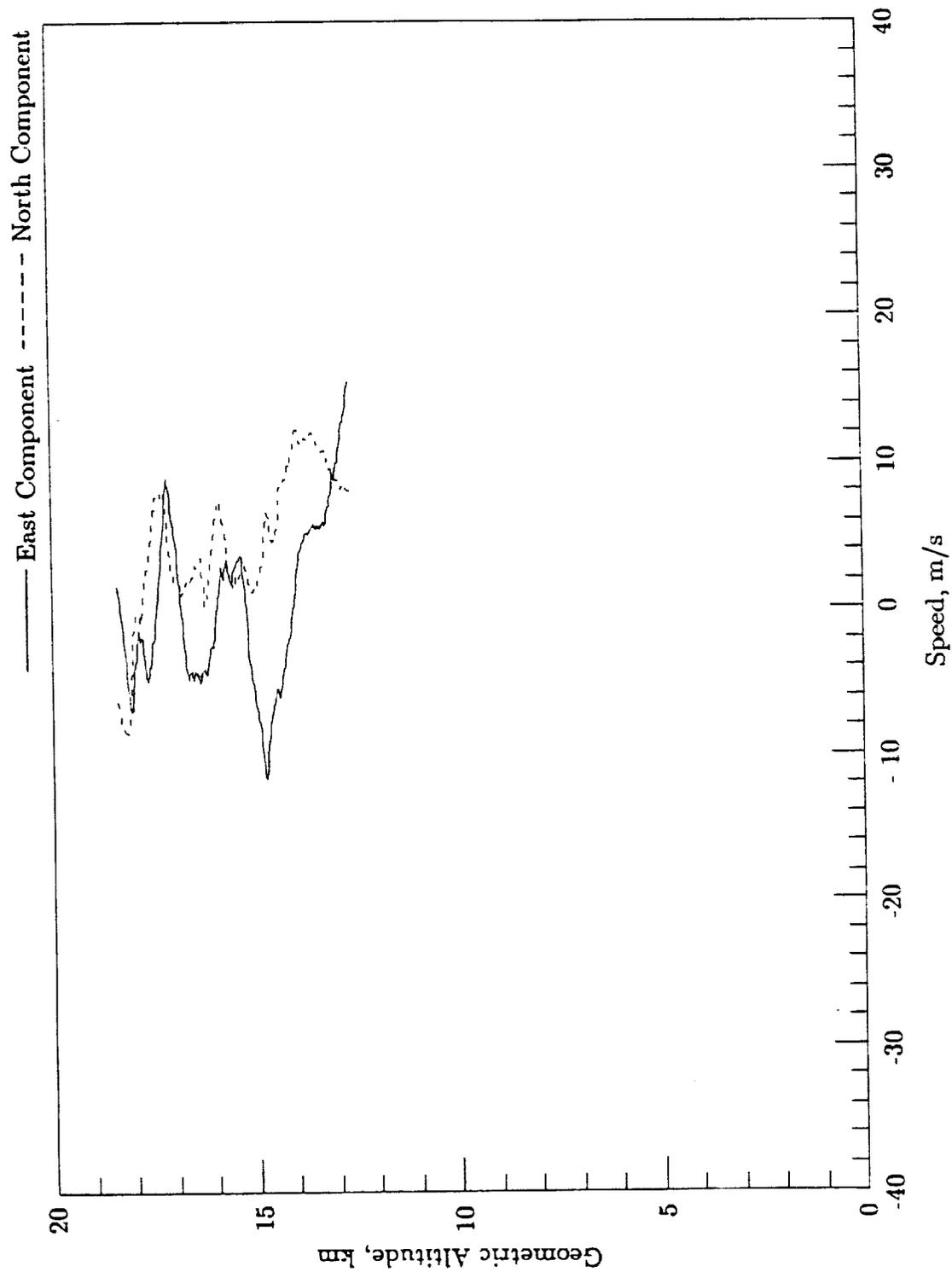


Figure 3.38 Wind velocity horizontal components from F-104 data, Descent # 1, 01-Aug-88, Dryden Flight Research Facility, INS ground speed.

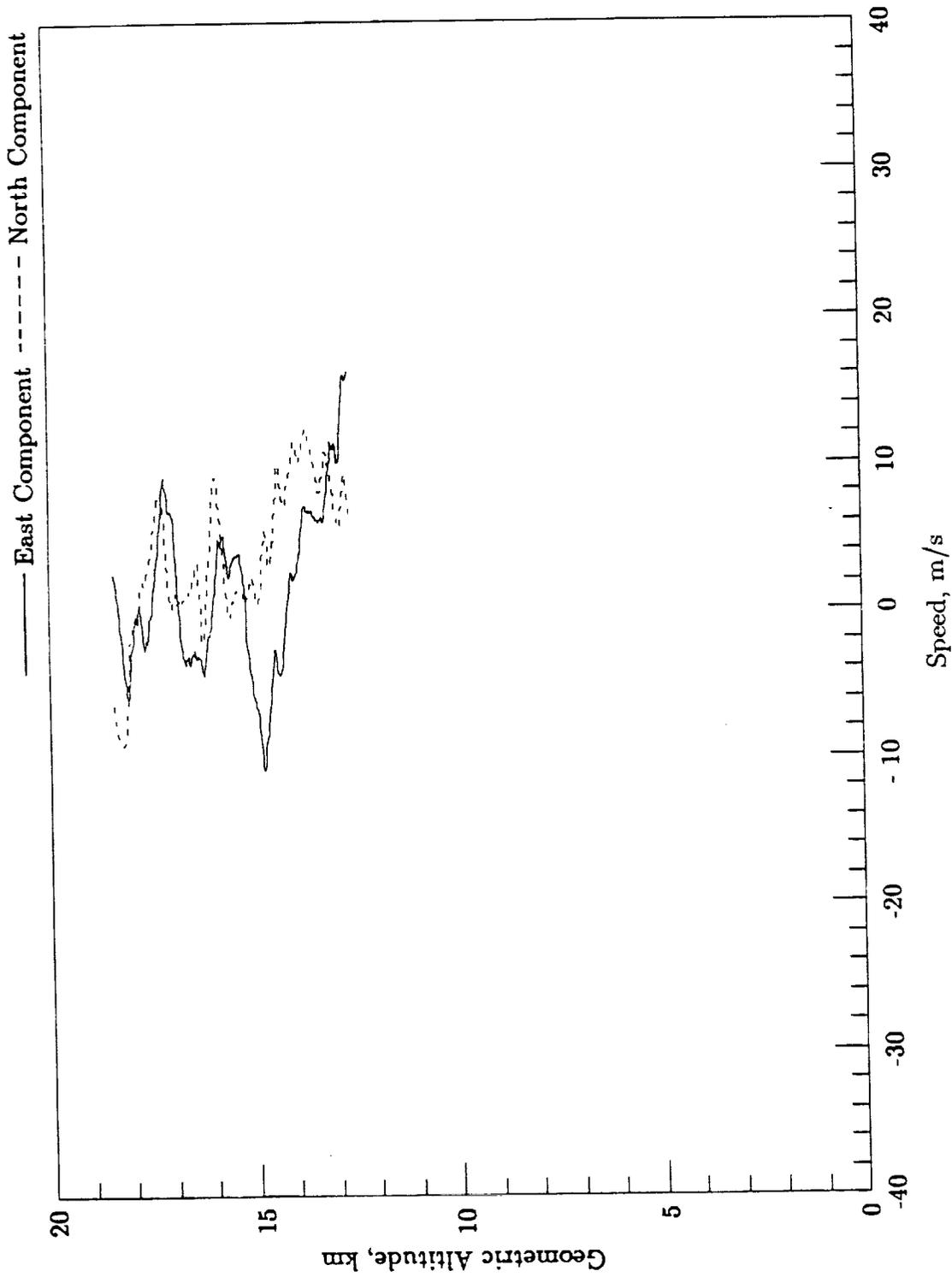
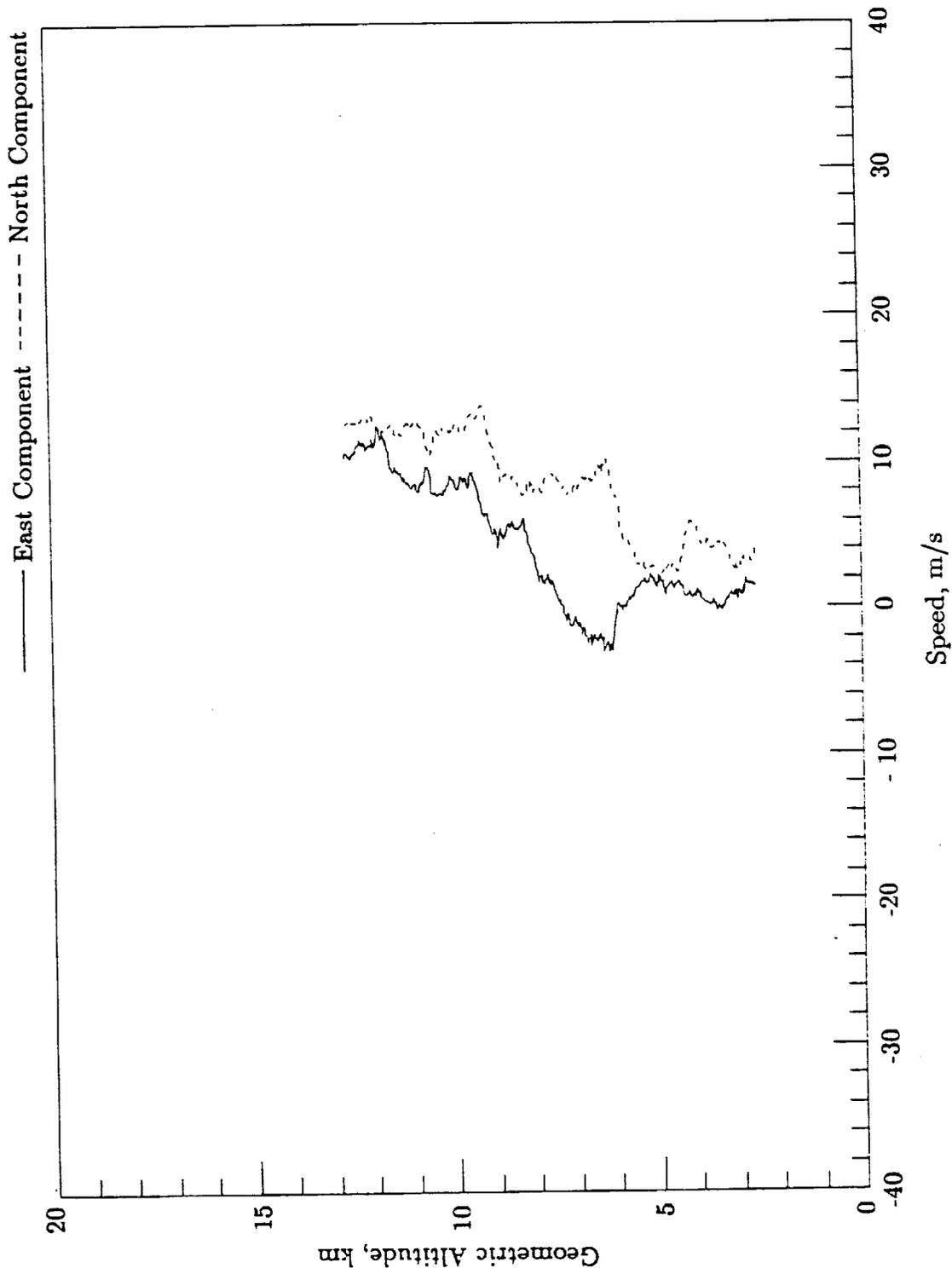


Figure 3.39 Wind velocity horizontal components from F-104 data, Descent # 1, 01-Aug-88, Dryden Flight Research Facility, radar ground speed.



**Figure 3.40** Wind velocity horizontal components from F-104 data, Descent # 2, 01-Aug-88, Dryden Flight Research Facility, INS ground speed.

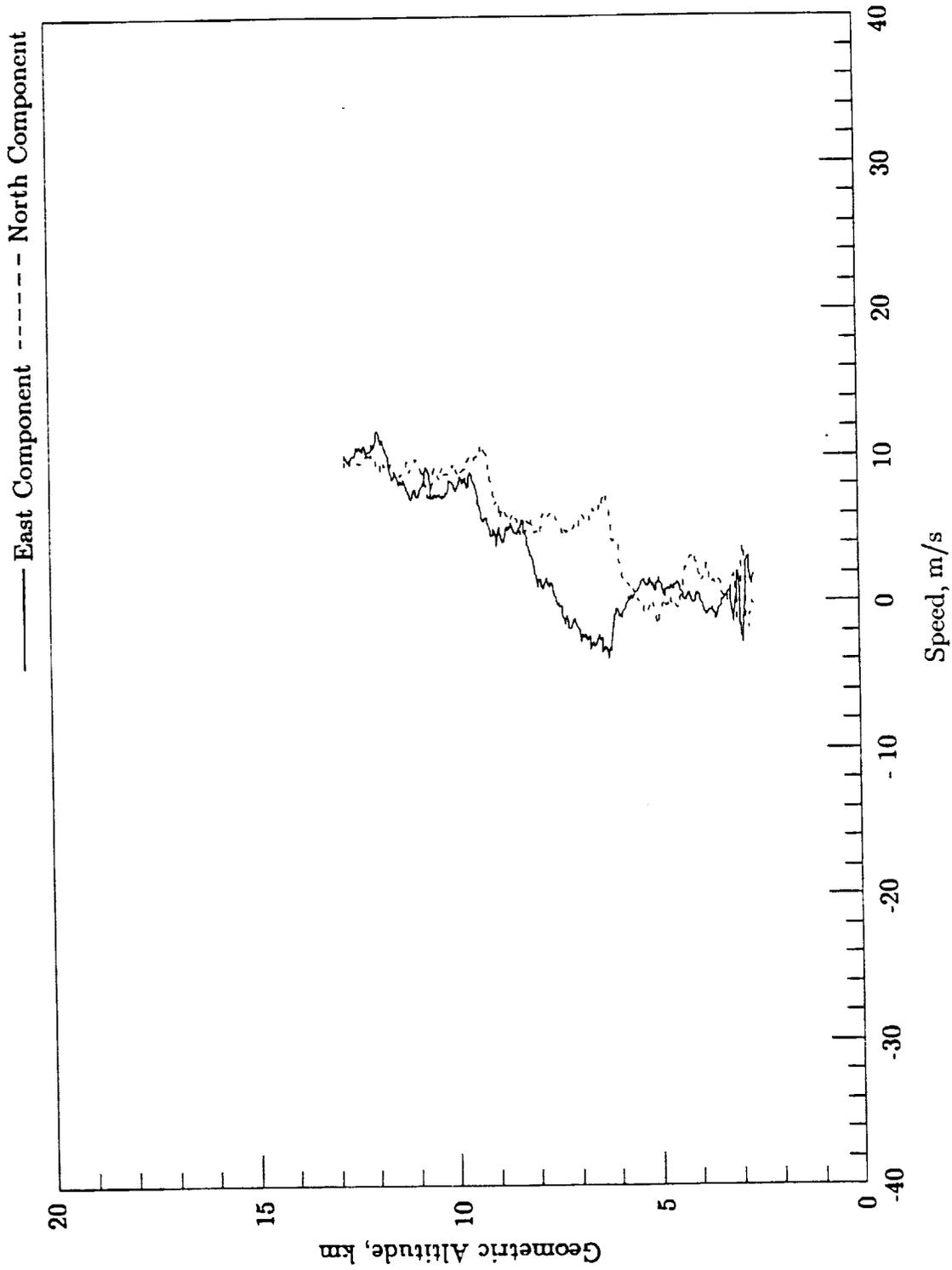
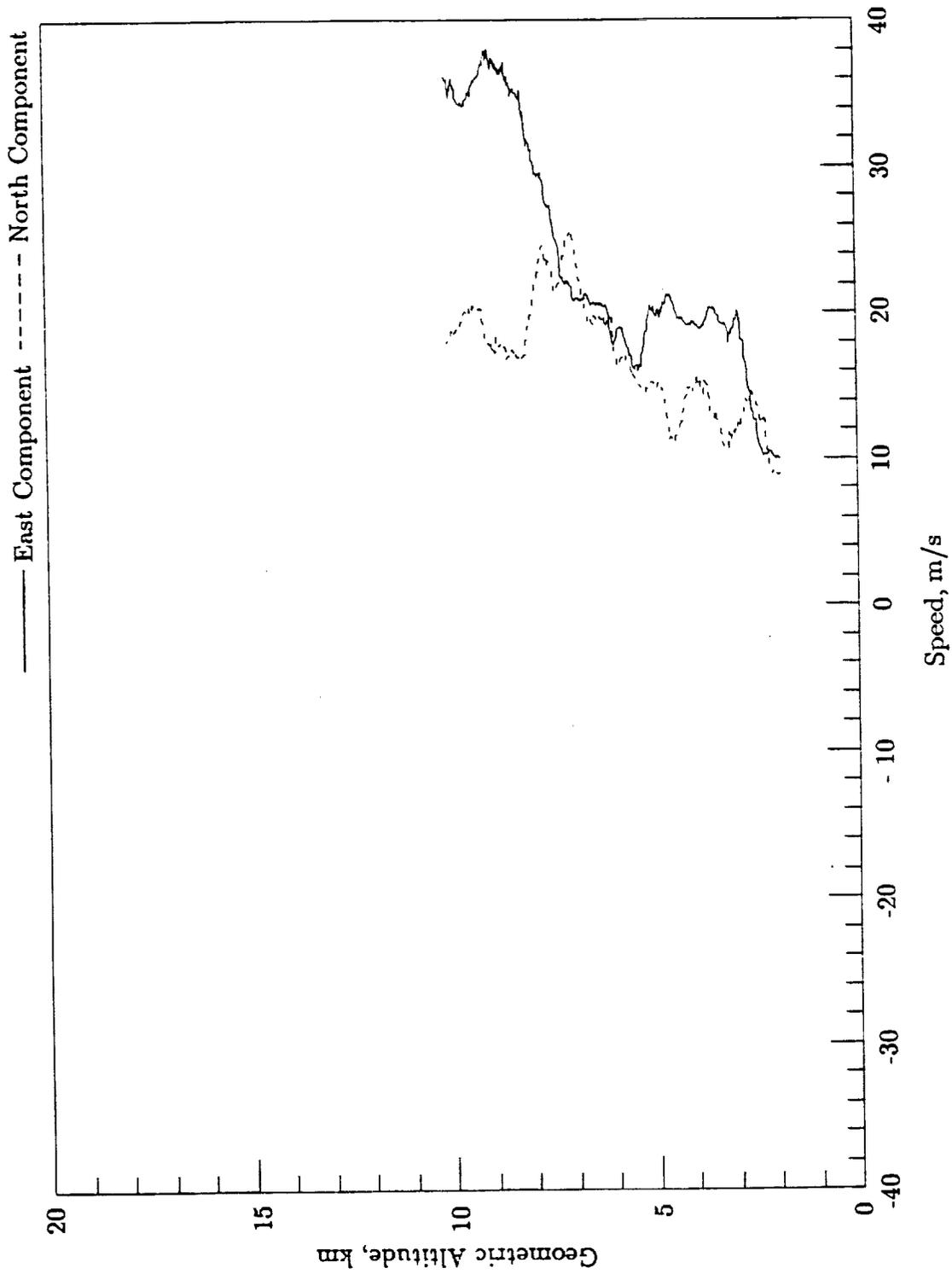


Figure 3.41 Wind velocity horizontal components from F-104 data, Descent # 2, 01-Aug-88, Dryden Flight Research Facility, radar ground speed.



**Figure 3.42** Wind velocity horizontal components from F-104 data, Climb # 1, 21-Apr-89, Dryden Flight Research Facility, INS ground speed.

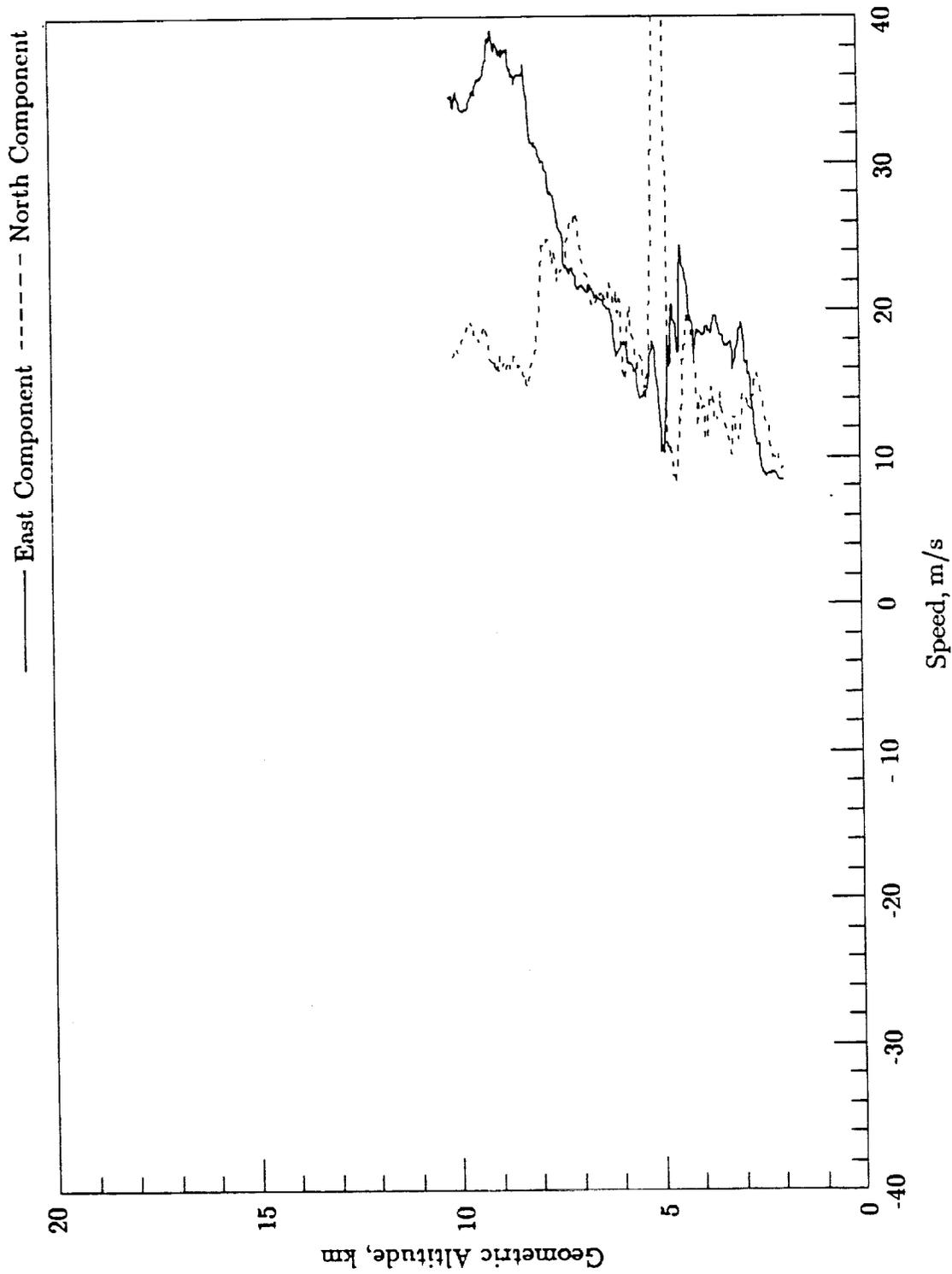
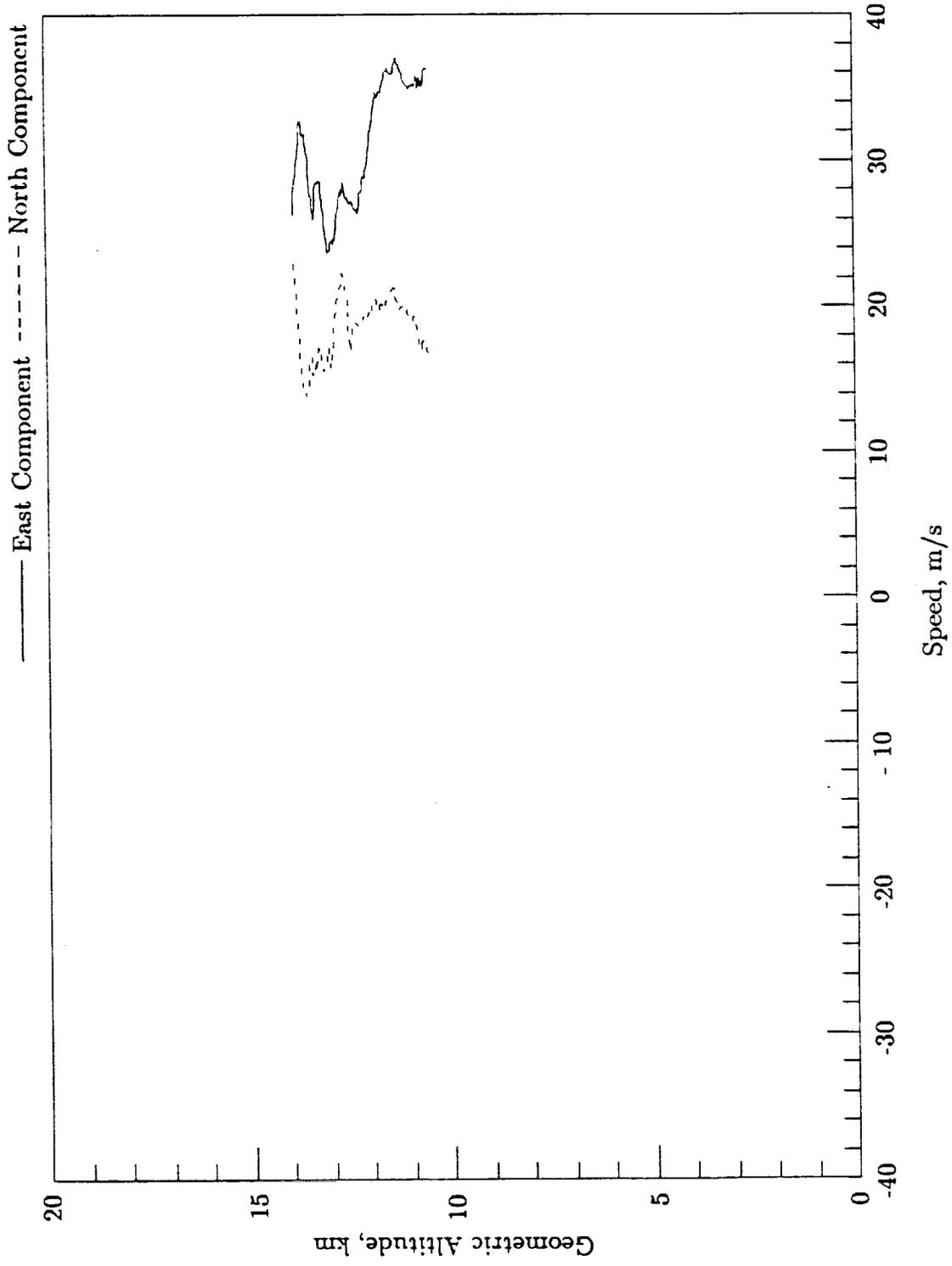


Figure 3.43 Wind velocity horizontal components from F-104 data, Climb # 1, 21-Apr-89, Dryden Flight Research Facility, radar ground speed.



**Figure 3.44** Wind velocity horizontal components from F-104 data, Climb # 2, 21-Apr-89, Dryden Flight Research Facility, INS ground speed.

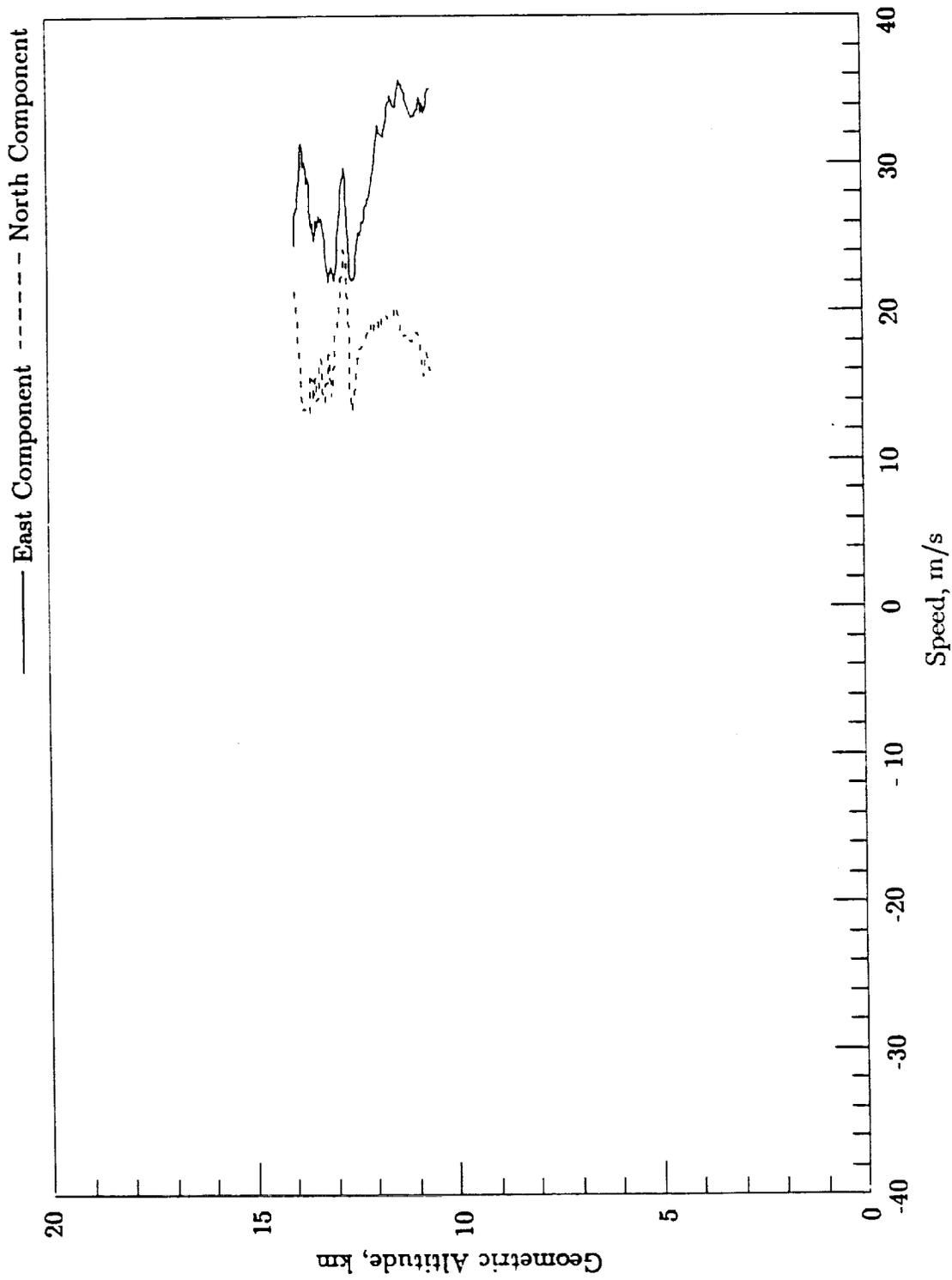
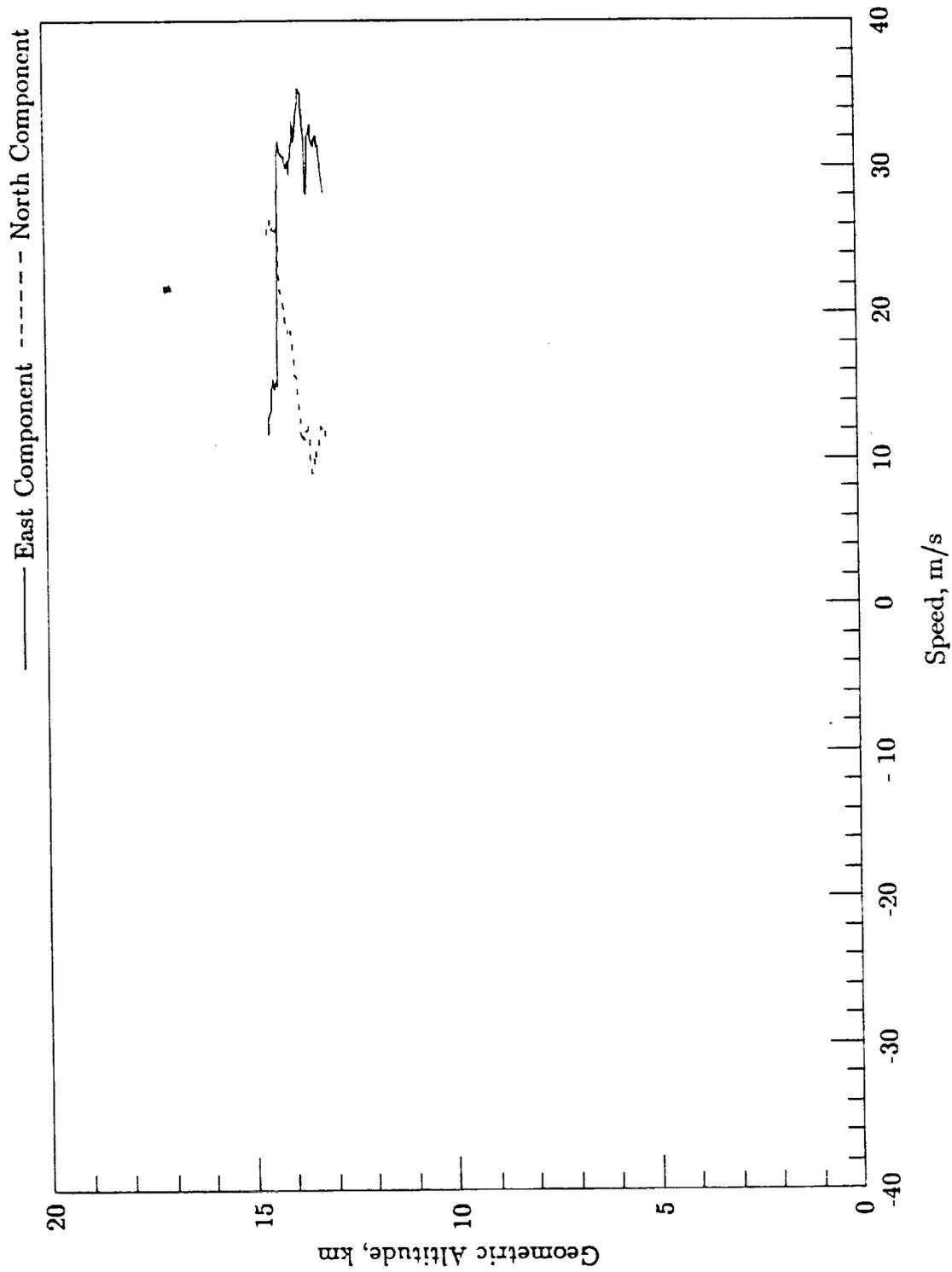
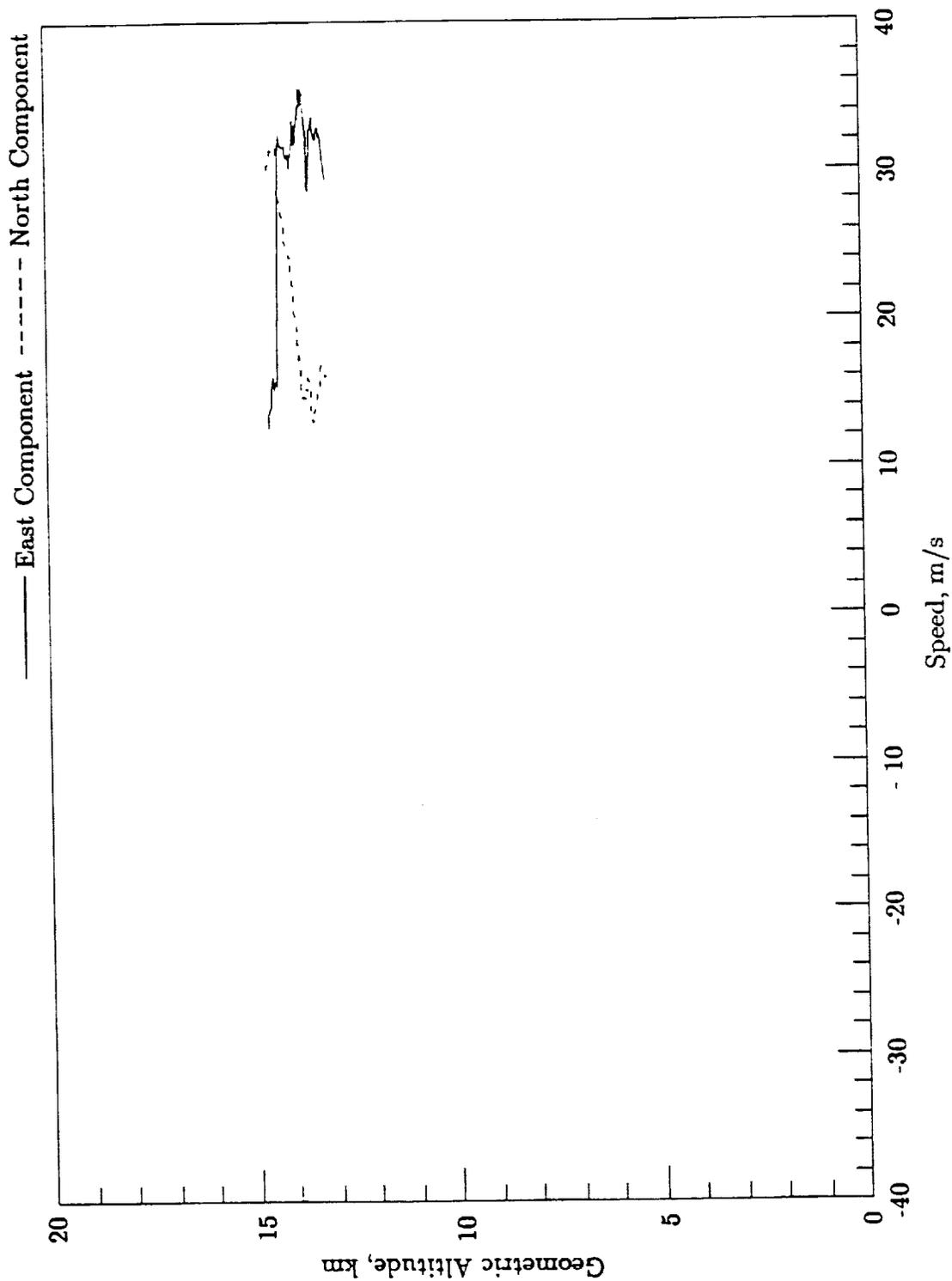


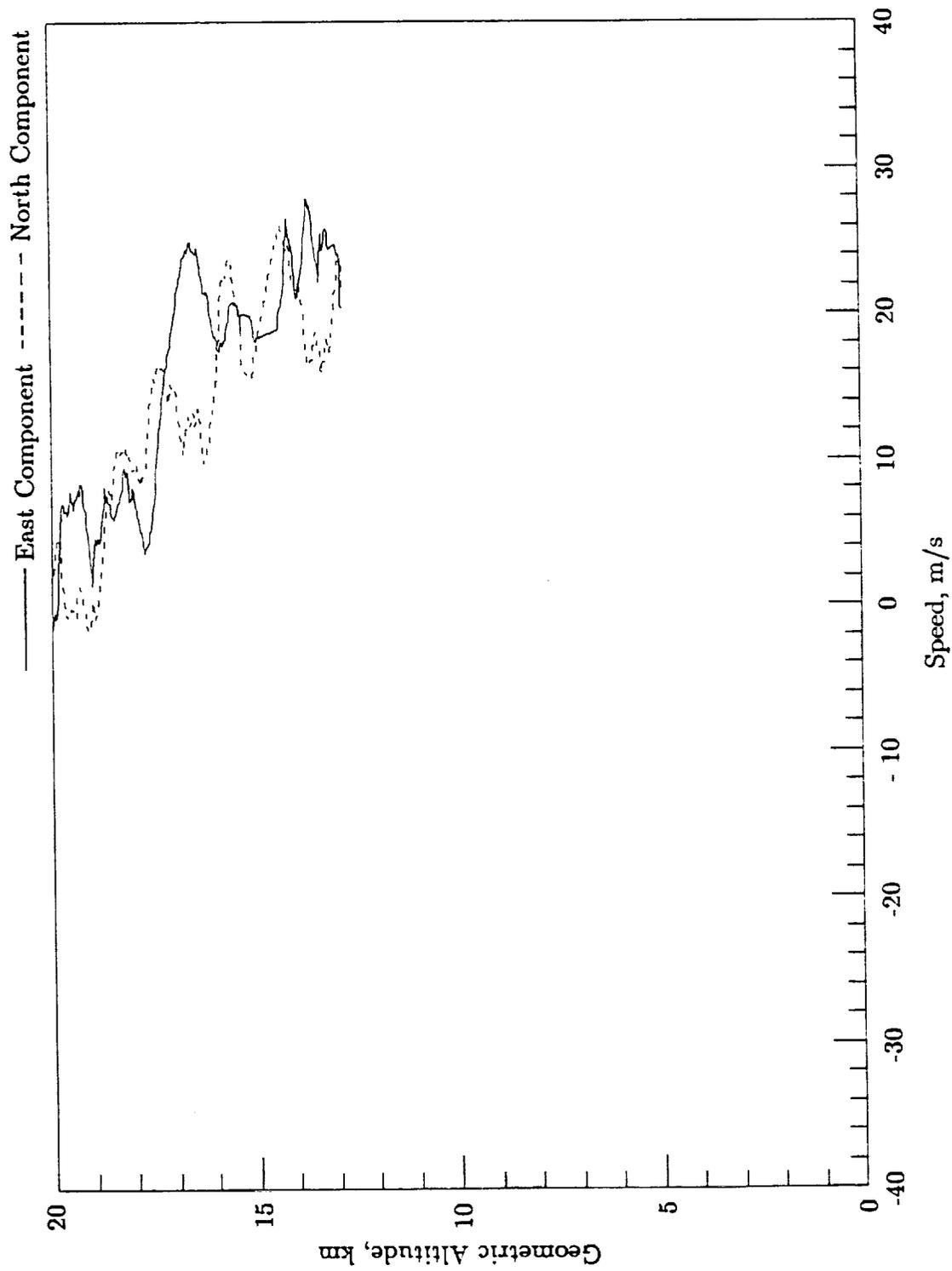
Figure 3.45 Wind velocity horizontal components from F-104 data, Climb # 2, 21-Apr-89, Dryden Flight Research Facility, radar ground speed.



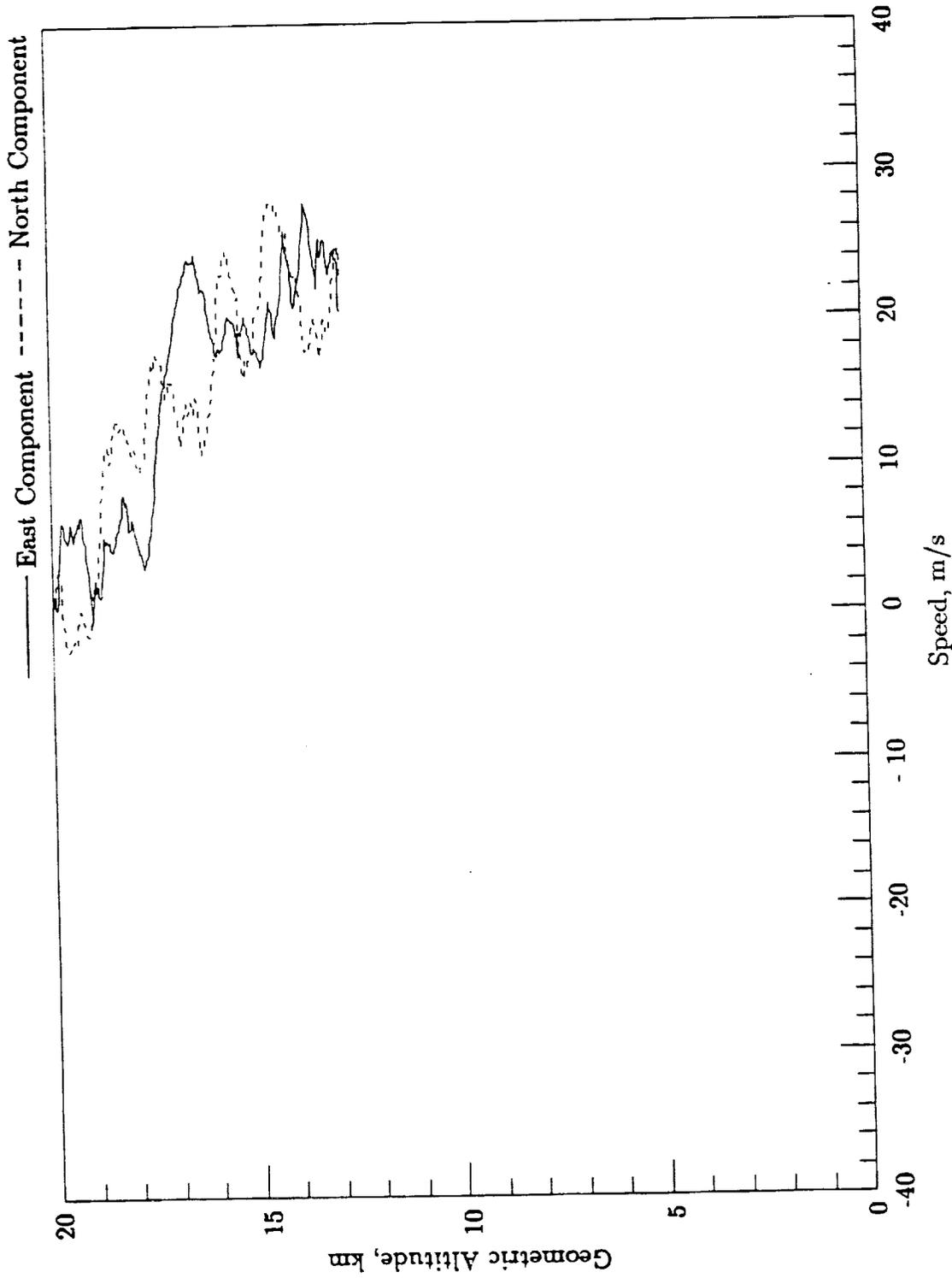
**Figure 3.46** Wind velocity horizontal components from F-104 data, Climb # 3, 21-Apr-89, Dryden Flight Research Facility, INS ground speed.



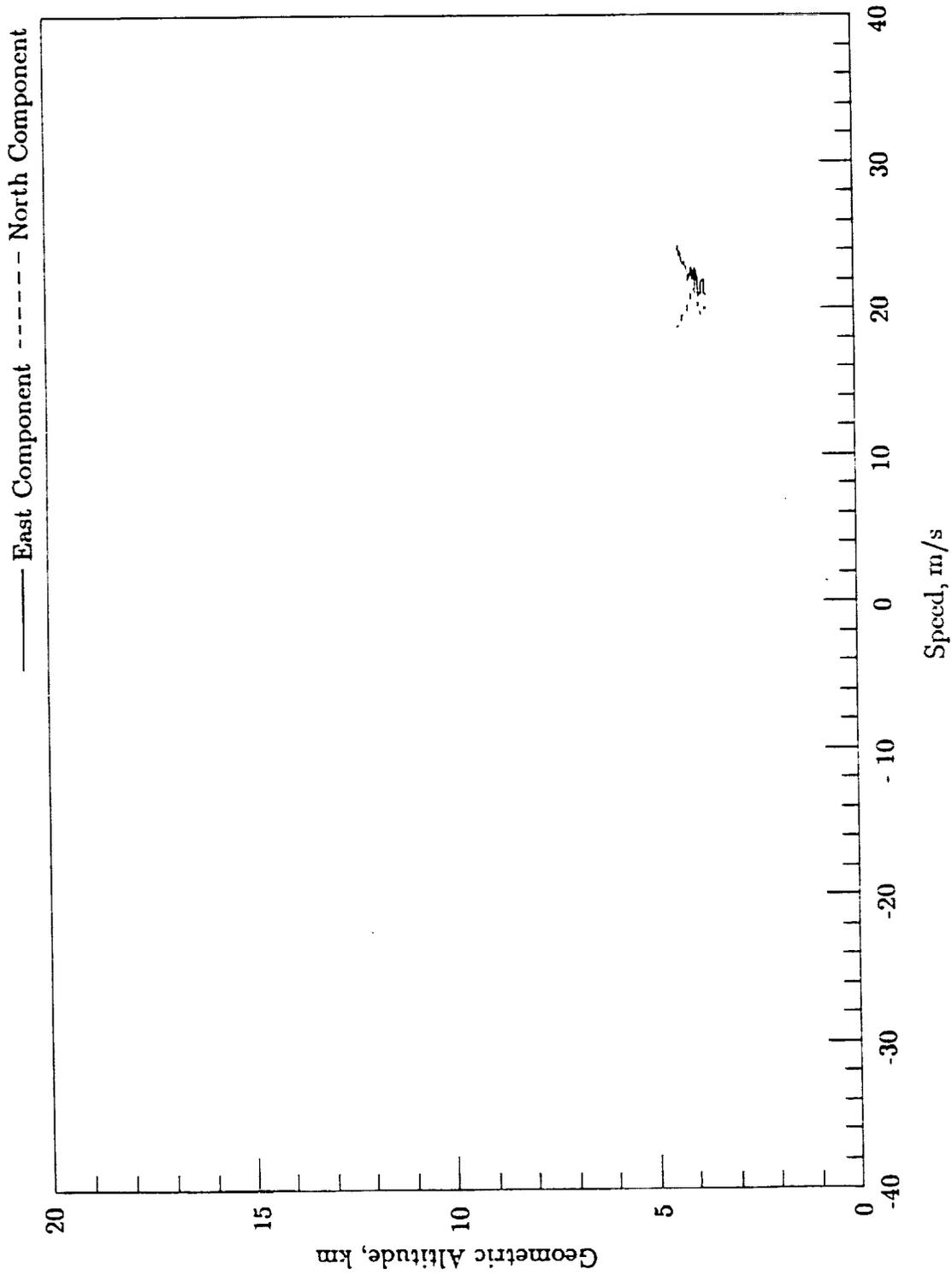
**Figure 3.47** Wind velocity horizontal components from F-104 data, Climb # 3, 21-Apr-89, Dryden Flight Research Facility, radar ground speed.



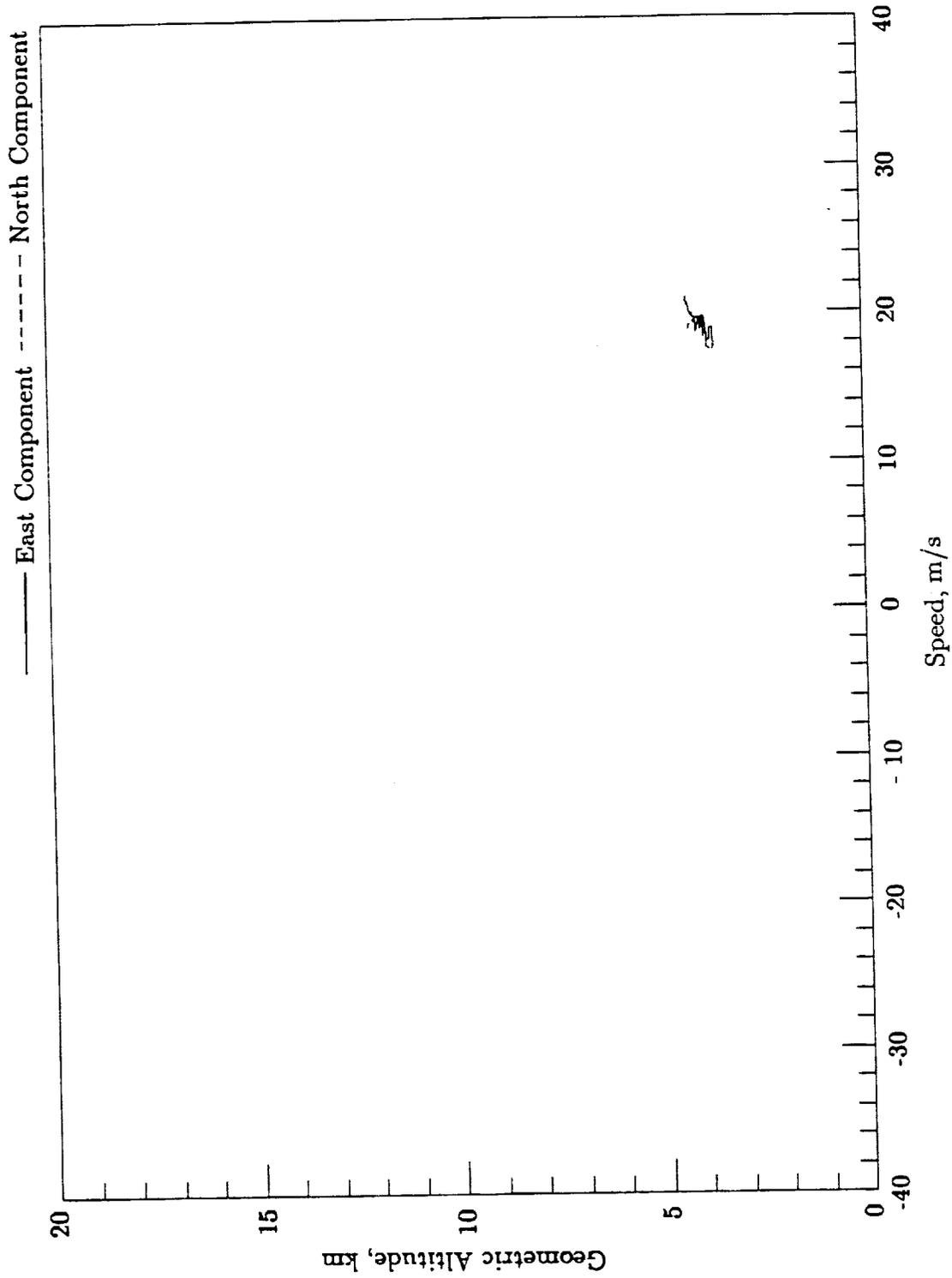
**Figure 3.48** Wind velocity horizontal components from F-104 data, Descent # 1, 21-Apr-89, Dryden Flight Research Facility, INS ground speed.



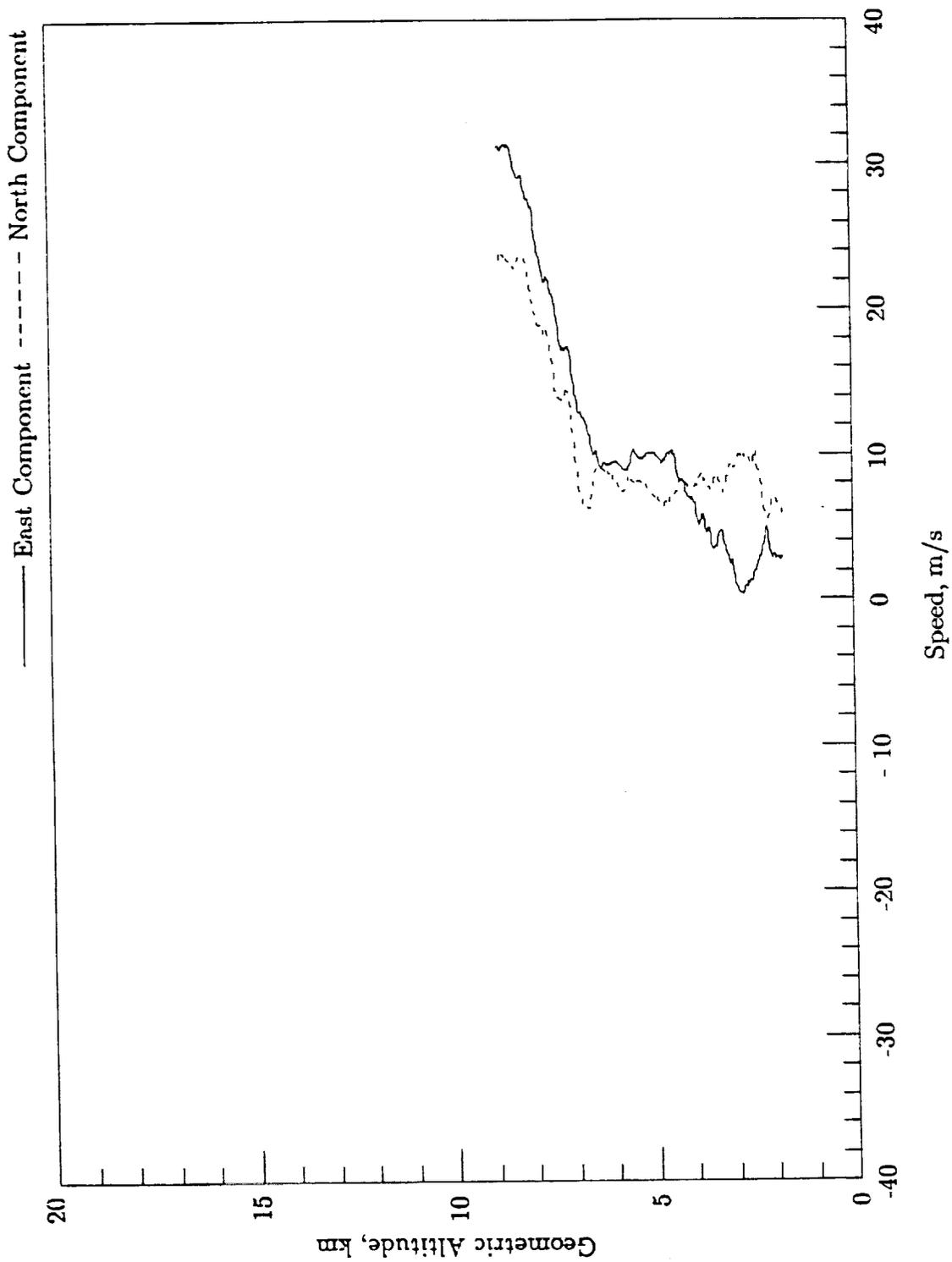
**Figure 3.49** Wind velocity horizontal components from F-104 data, Descent # 1, 21-Apr-89, Dryden Flight Research Facility, radar ground speed.



**Figure 3.50** Wind velocity horizontal components from F-104 data, Descent # 2, 21-Apr-89, Dryden Flight Research Facility, INS ground speed.



**Figure 3.51** Wind velocity horizontal components from F-104 data, Descent # 2, 21-Apr-89, Dryden Flight Research Facility, radar ground speed.



**Figure 3.52** Wind velocity horizontal components from F-104 data, Climb # 1, 25-Apr-89, Dryden Flight Research Facility, INS ground speed.

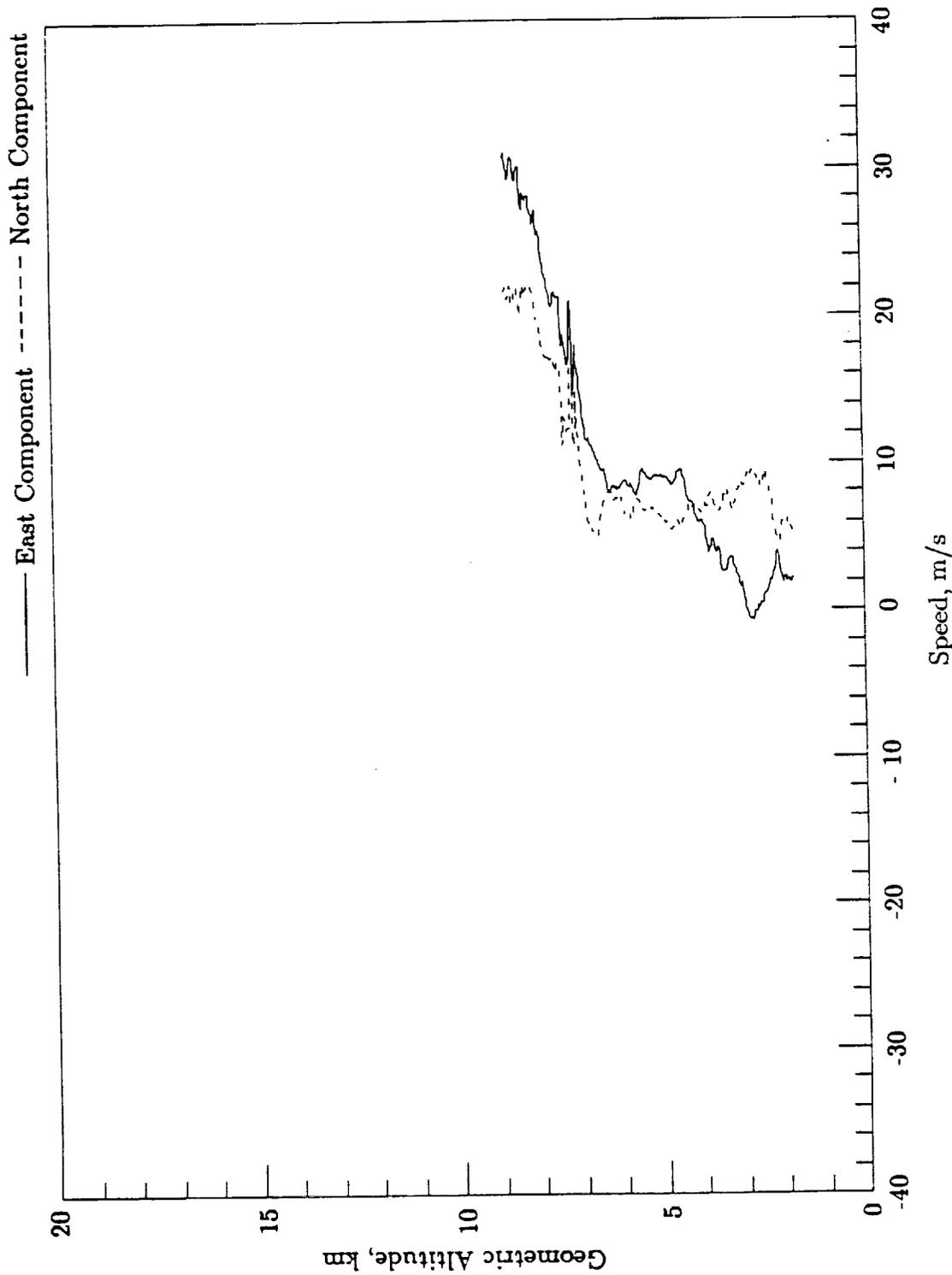


Figure 3.53 Wind velocity horizontal components from F-104 data, Climb # 1, 25-Apr-89, Dryden Flight Research Facility, radar ground speed.

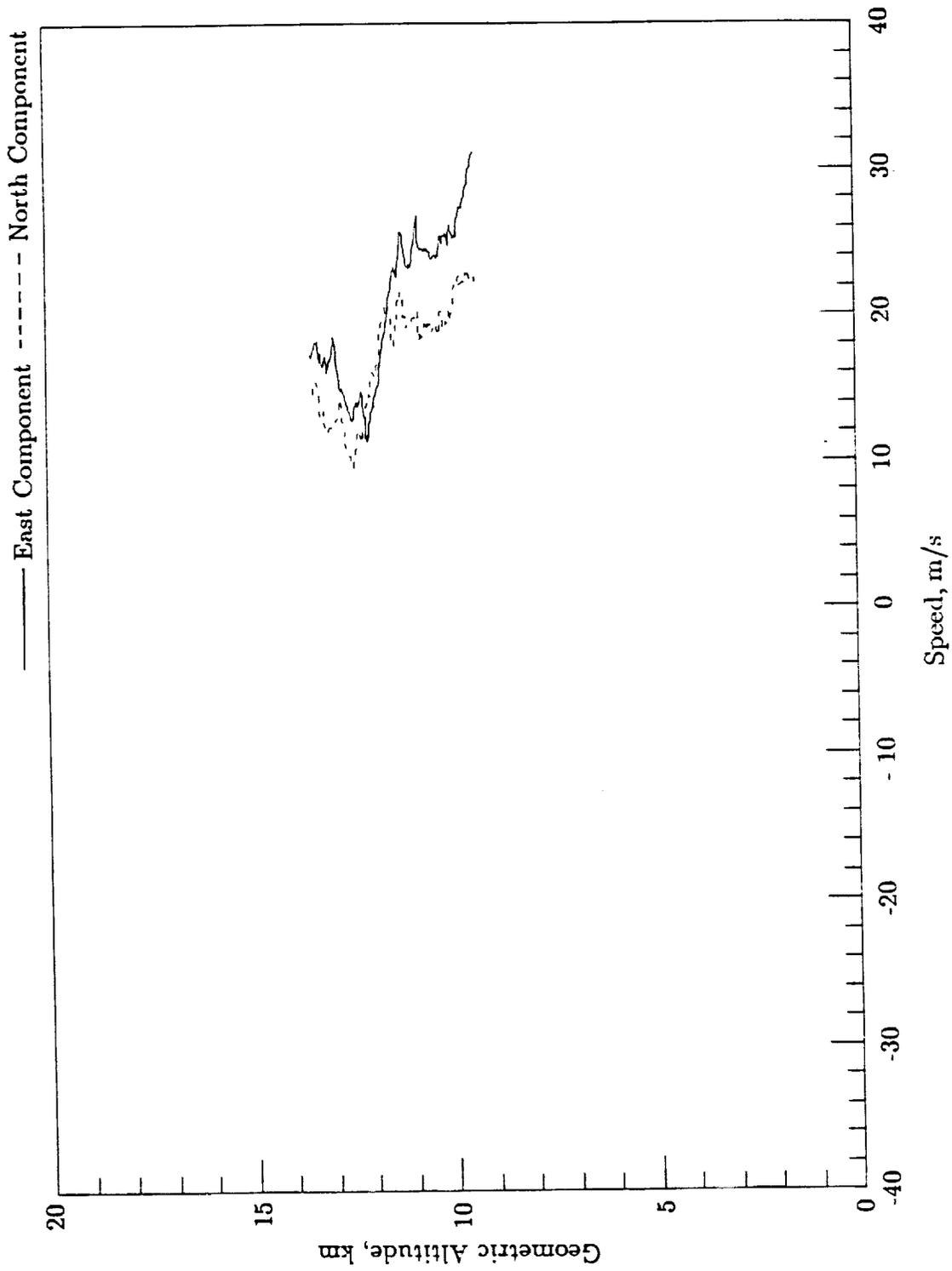


Figure 3.54 Wind velocity horizontal components from F-104 data, Climb # 2, 25-Apr-89, Dryden Flight Research Facility, INS ground speed.

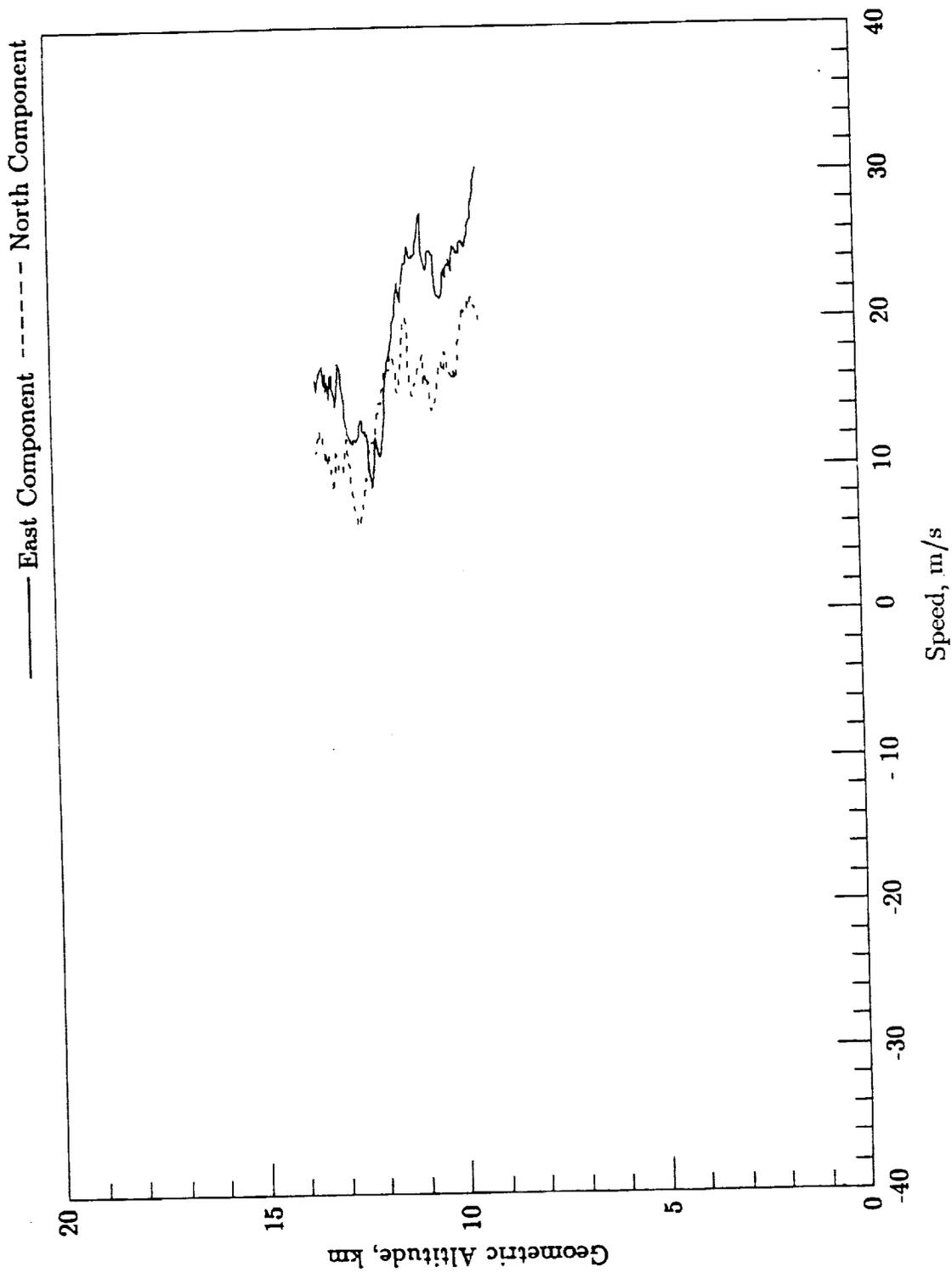
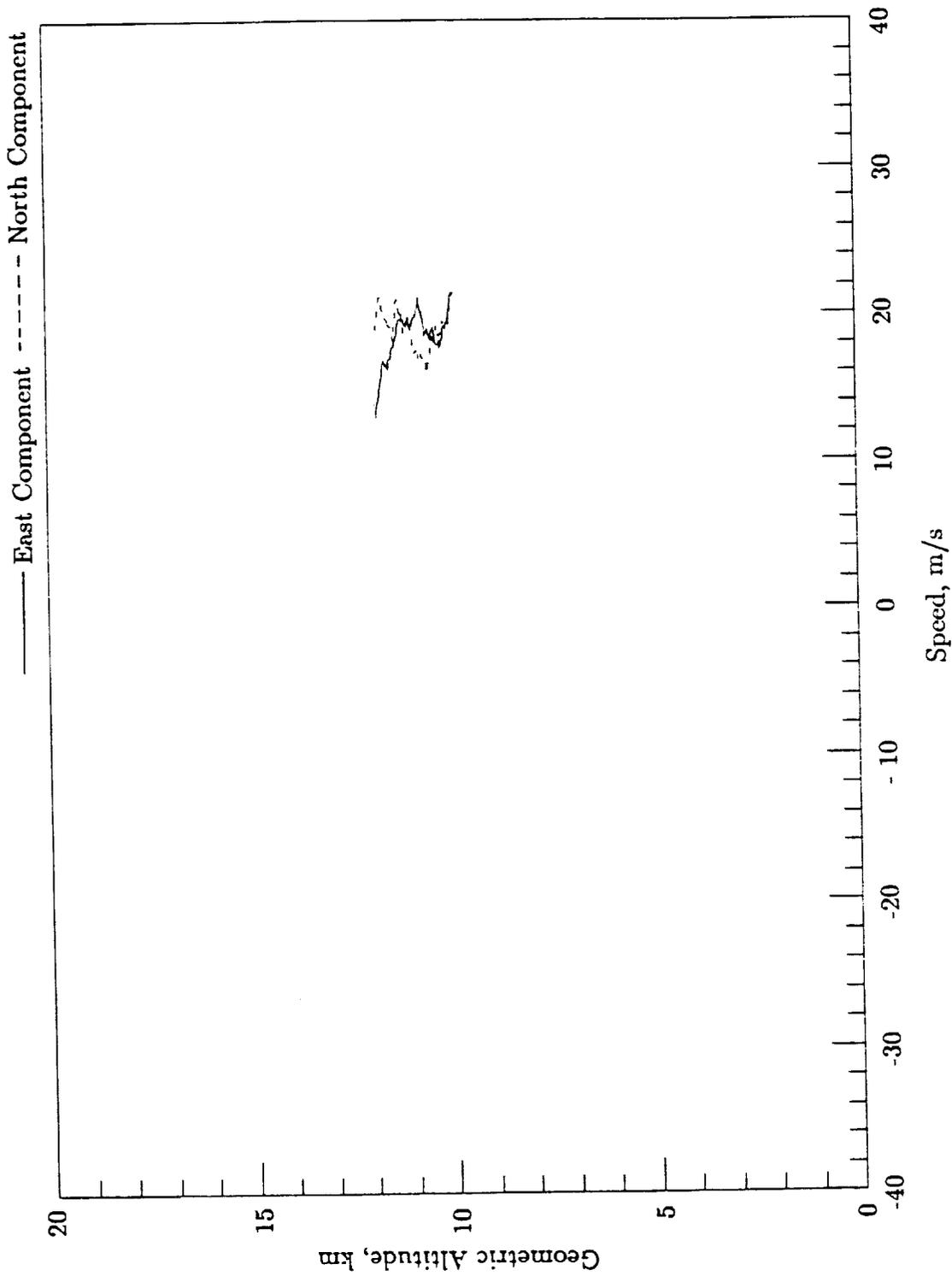


Figure 3.55 Wind velocity horizontal components from F-104 data, Climb # 2, 25-Apr-89, Dryden Flight Research Facility, radar ground speed.



**Figure 3.56** Wind velocity horizontal components from F-104 data, Climb # 3, 25-Apr-89, Dryden Flight Research Facility, INS ground speed.

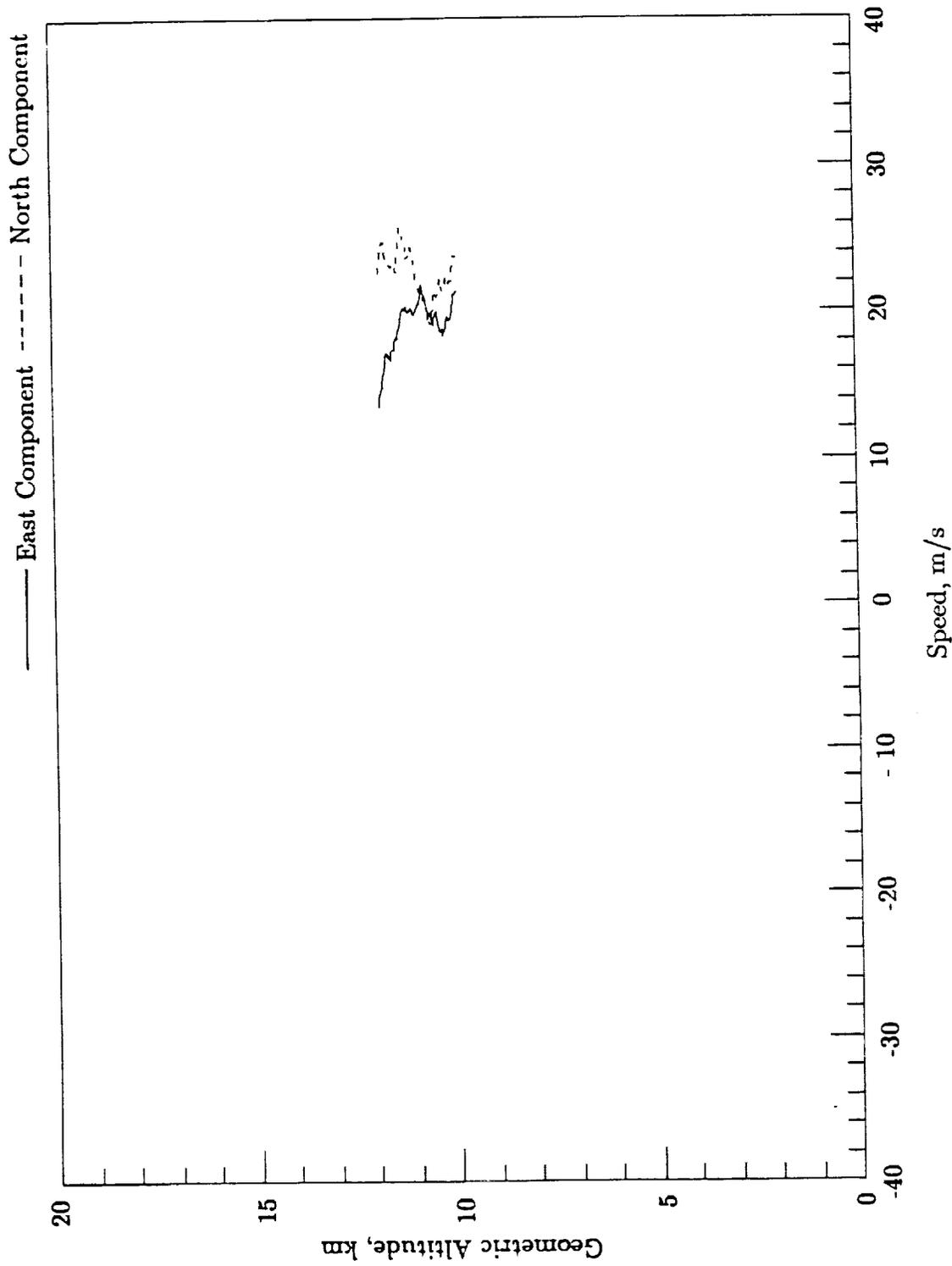
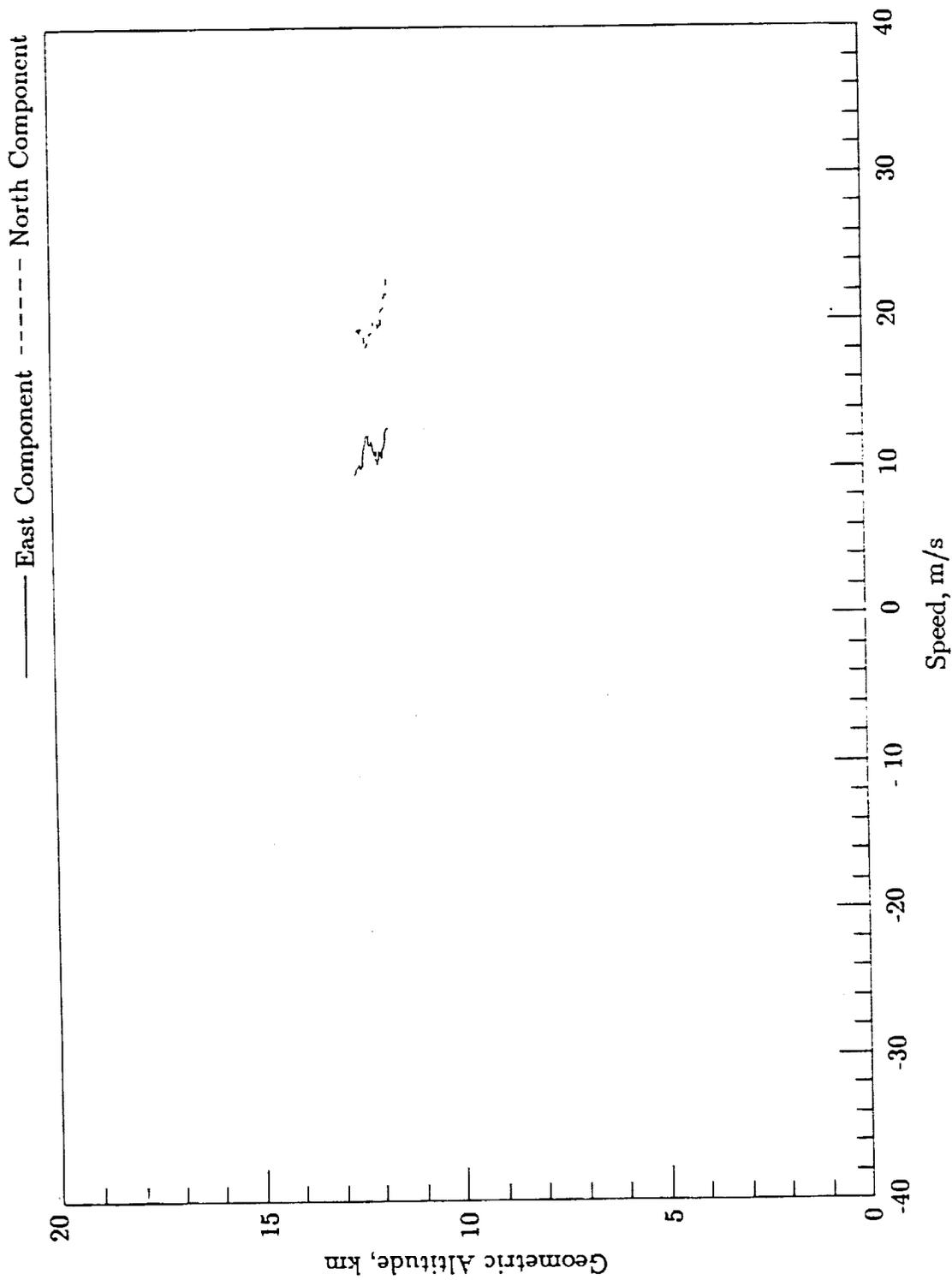


Figure 3.57 Wind velocity horizontal components from F-104 data, Climb # 3, 25-Apr-89, Dryden Flight Research Facility, radar ground speed.



**Figure 3.58** Wind velocity horizontal components from F-104 data, Descent # 1, 25-Apr-89, Dryden Flight Research Facility, INS ground speed.

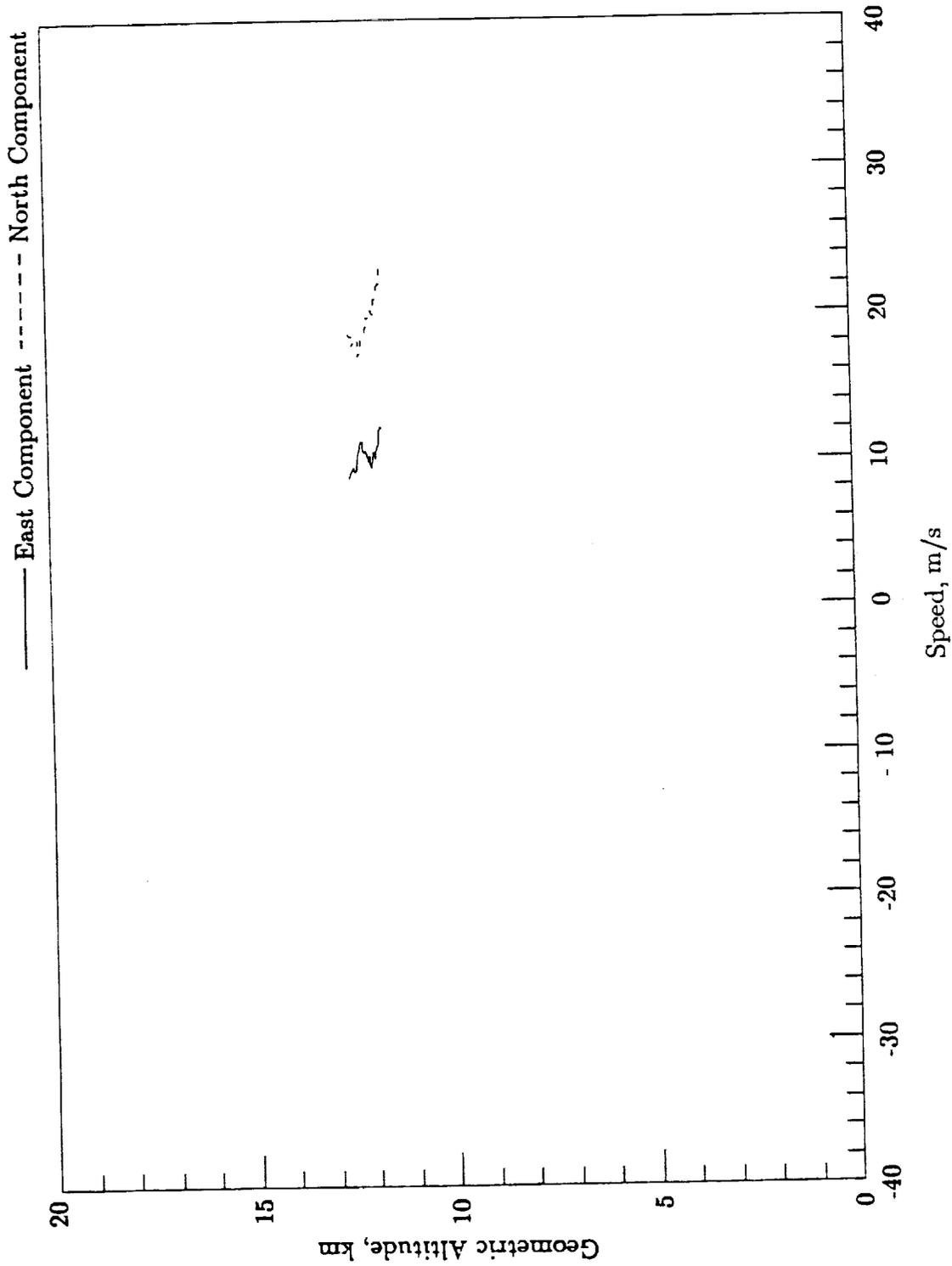
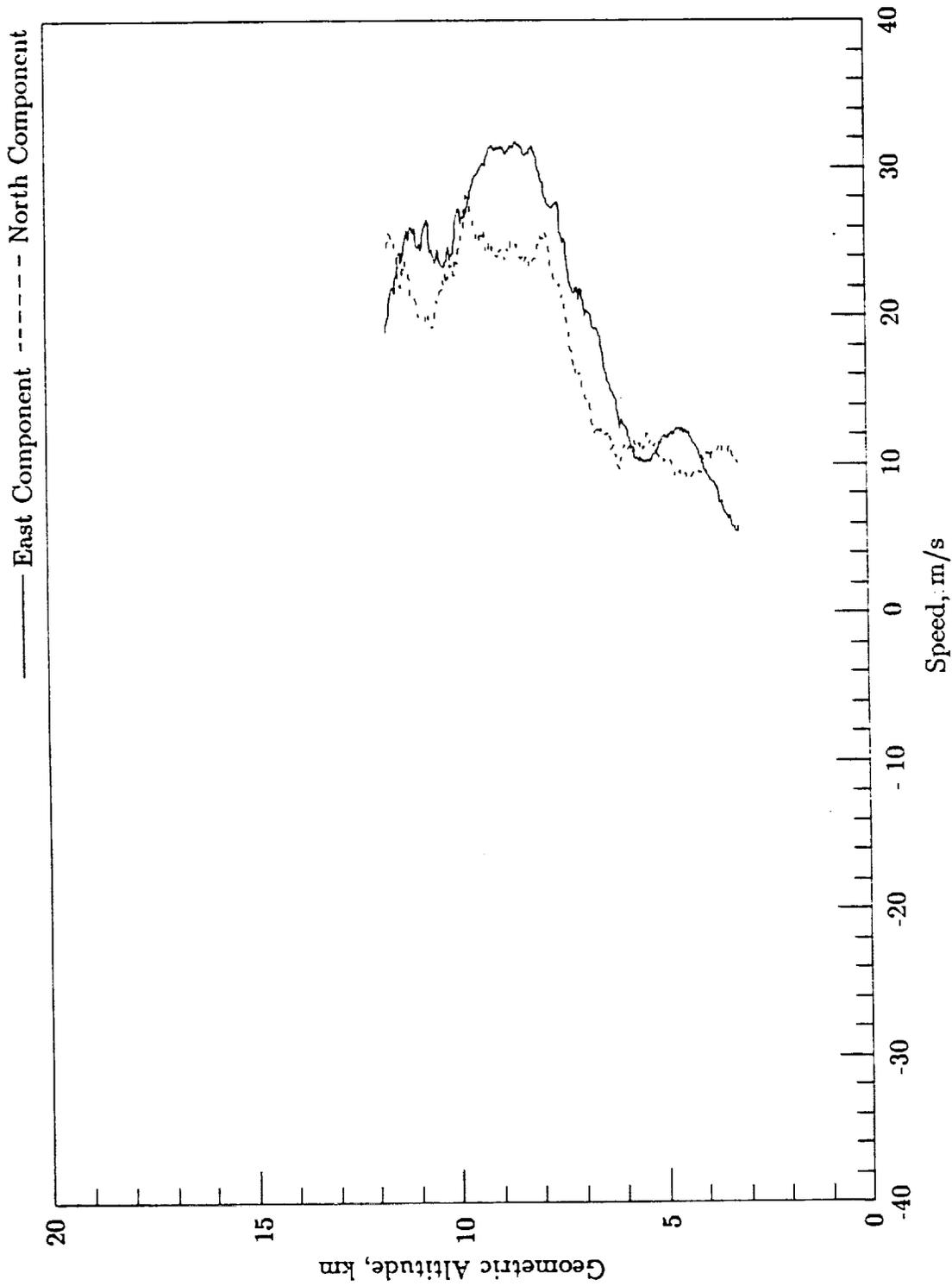


Figure 3.59 Wind velocity horizontal components from F-104 data, Descent # 1, 25-Apr-89, Dryden Flight Research Facility, radar ground speed.



**Figure 3.60** Wind velocity horizontal components from F-104 data, Descent # 2, 25-Apr-89, Dryden Flight Research Facility, INS ground speed.

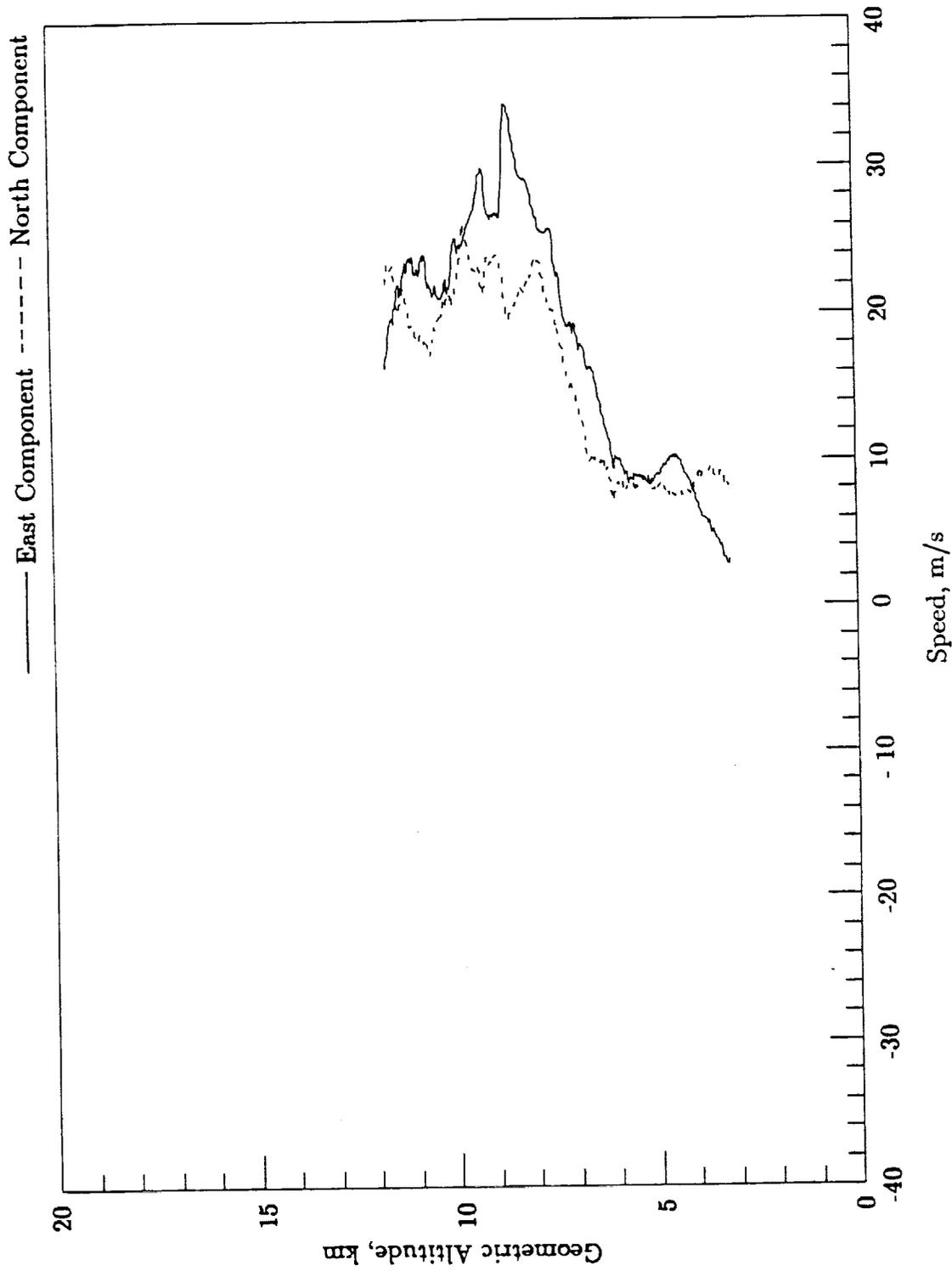
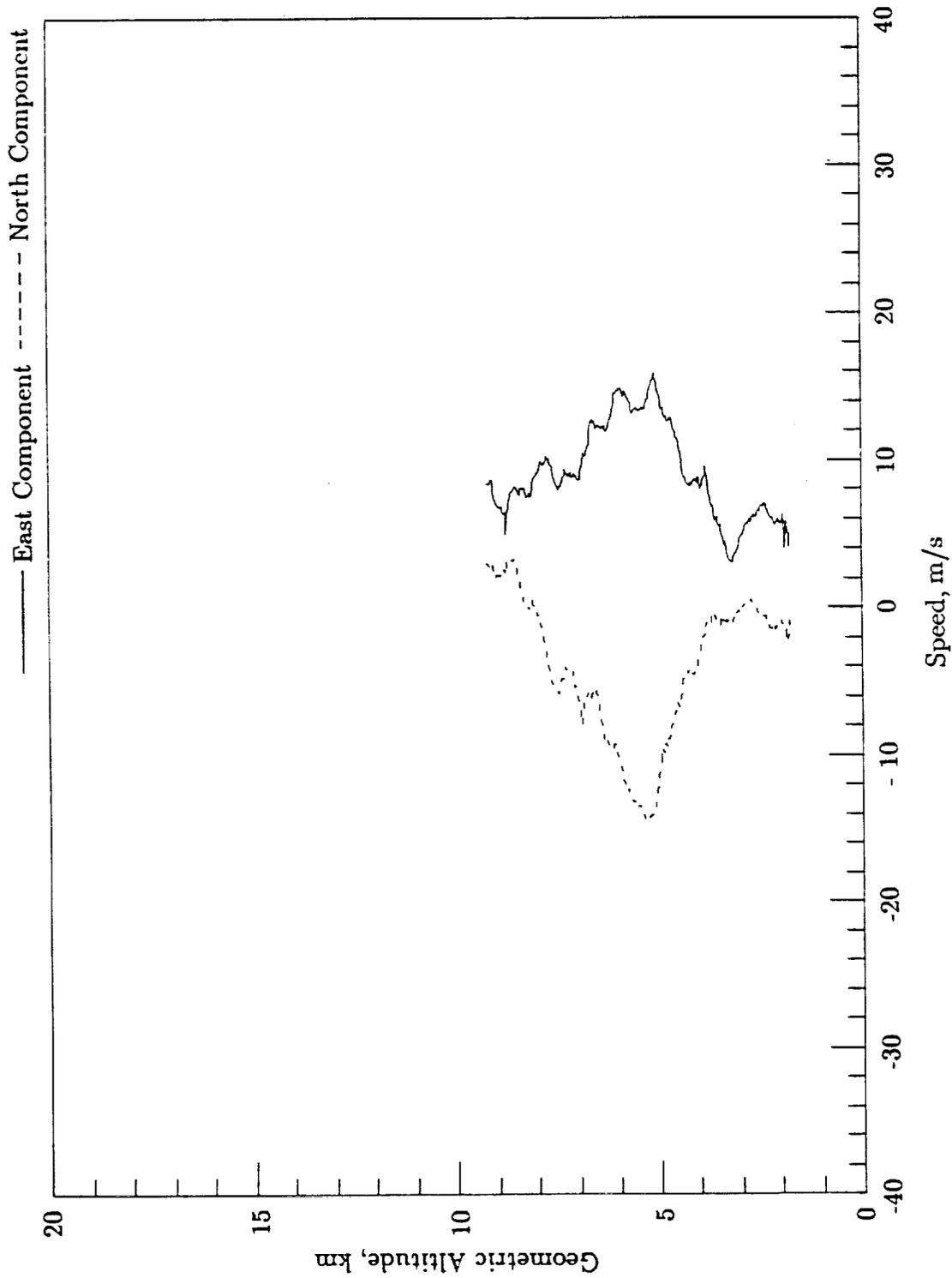


Figure 3.61 Wind velocity horizontal components from F-104 data, Descent # 2, 25-Apr-89, Dryden Flight Research Facility, radar ground speed.



**Figure 3.62** Wind velocity horizontal components from F-104 data, Climb # 1, 20-Jul-89, Dryden Flight Research Facility, INS ground speed.

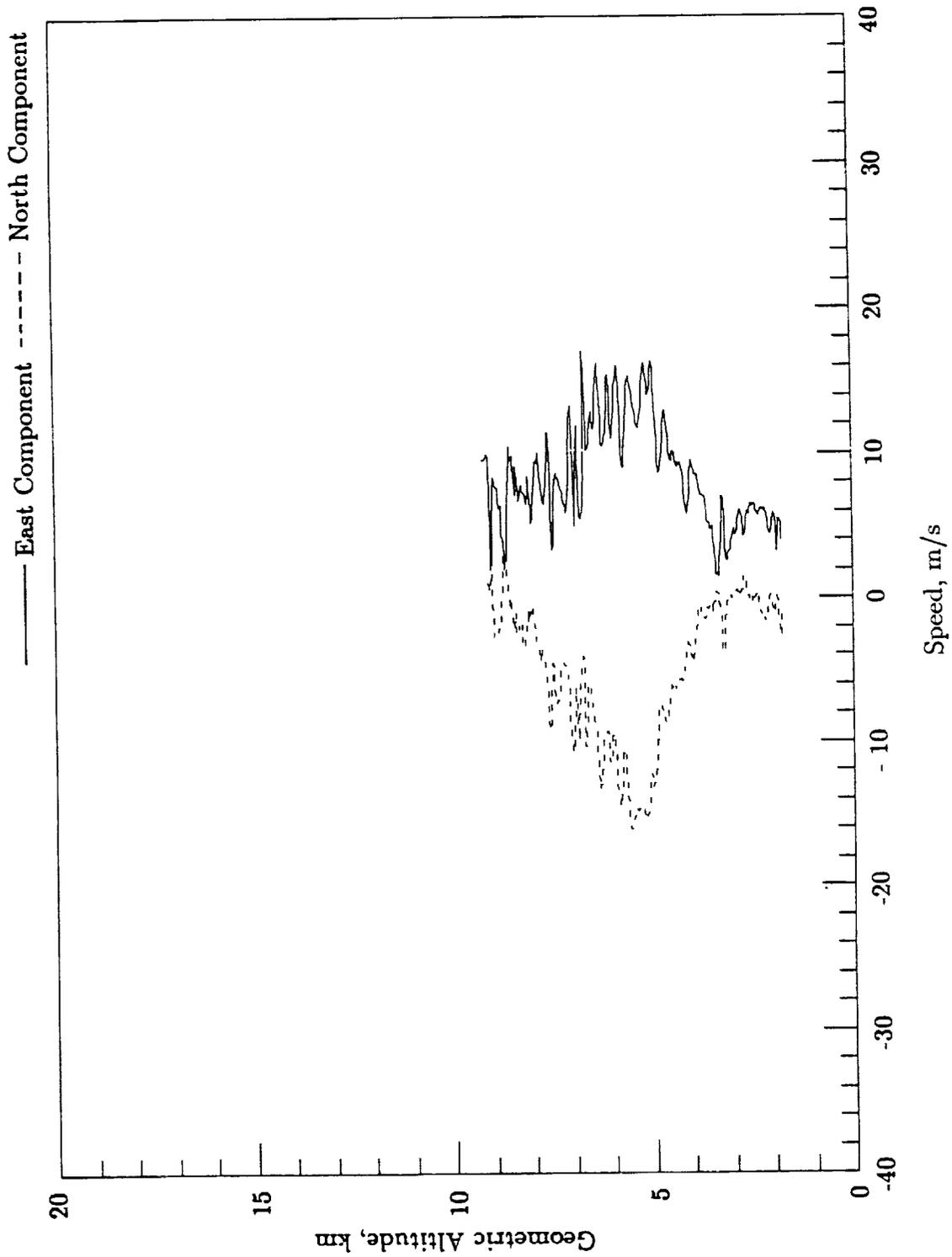


Figure 3.63 Wind velocity horizontal components from F-104 data, Climb # 1, 20-May-89, Dryden Flight Research Facility, radar ground speed.

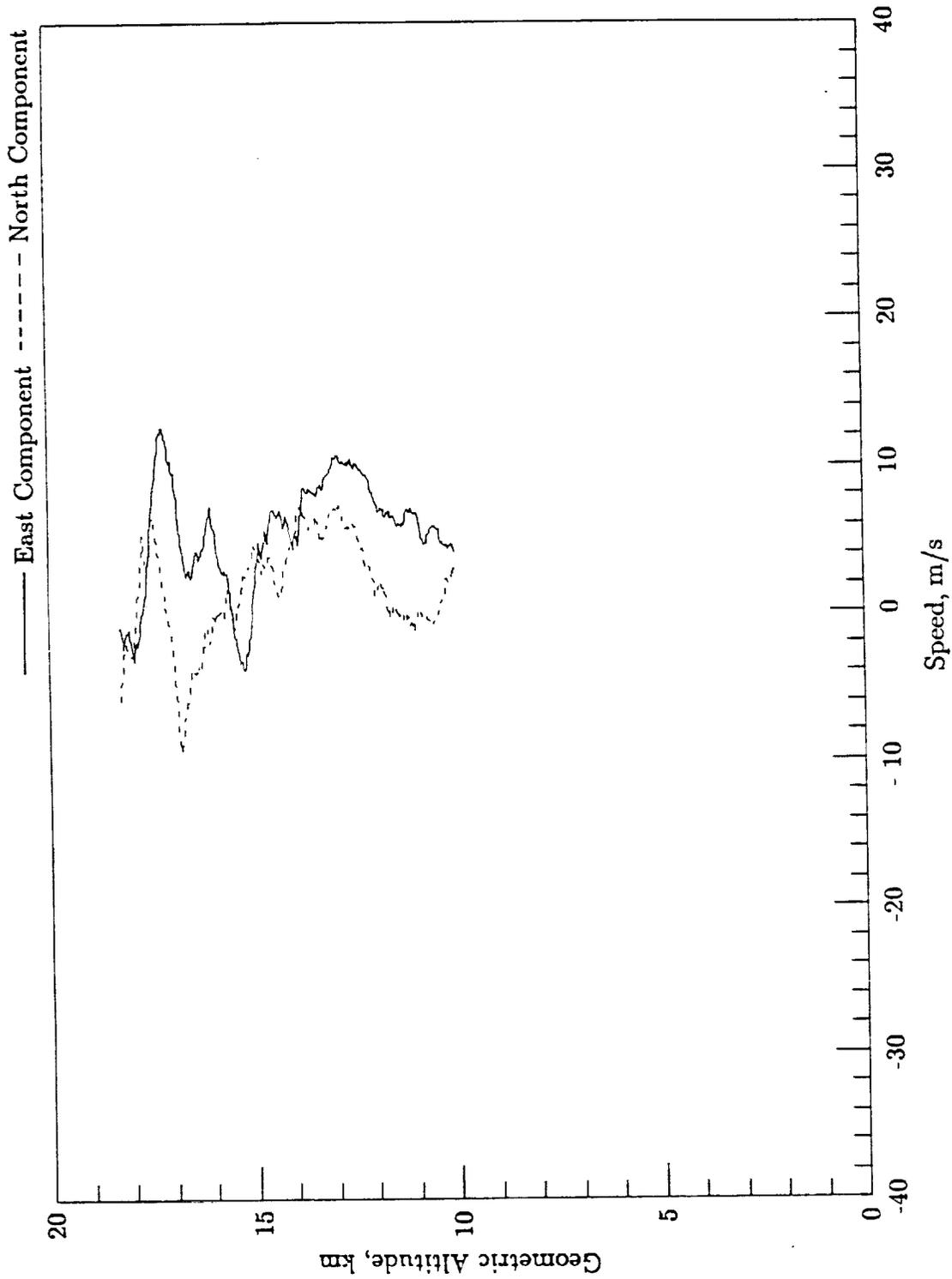


Figure 3.64 Wind velocity horizontal components from F-104 data, Climb # 2, 20-Jul-89, Dryden Flight Research Facility, INS ground speed.

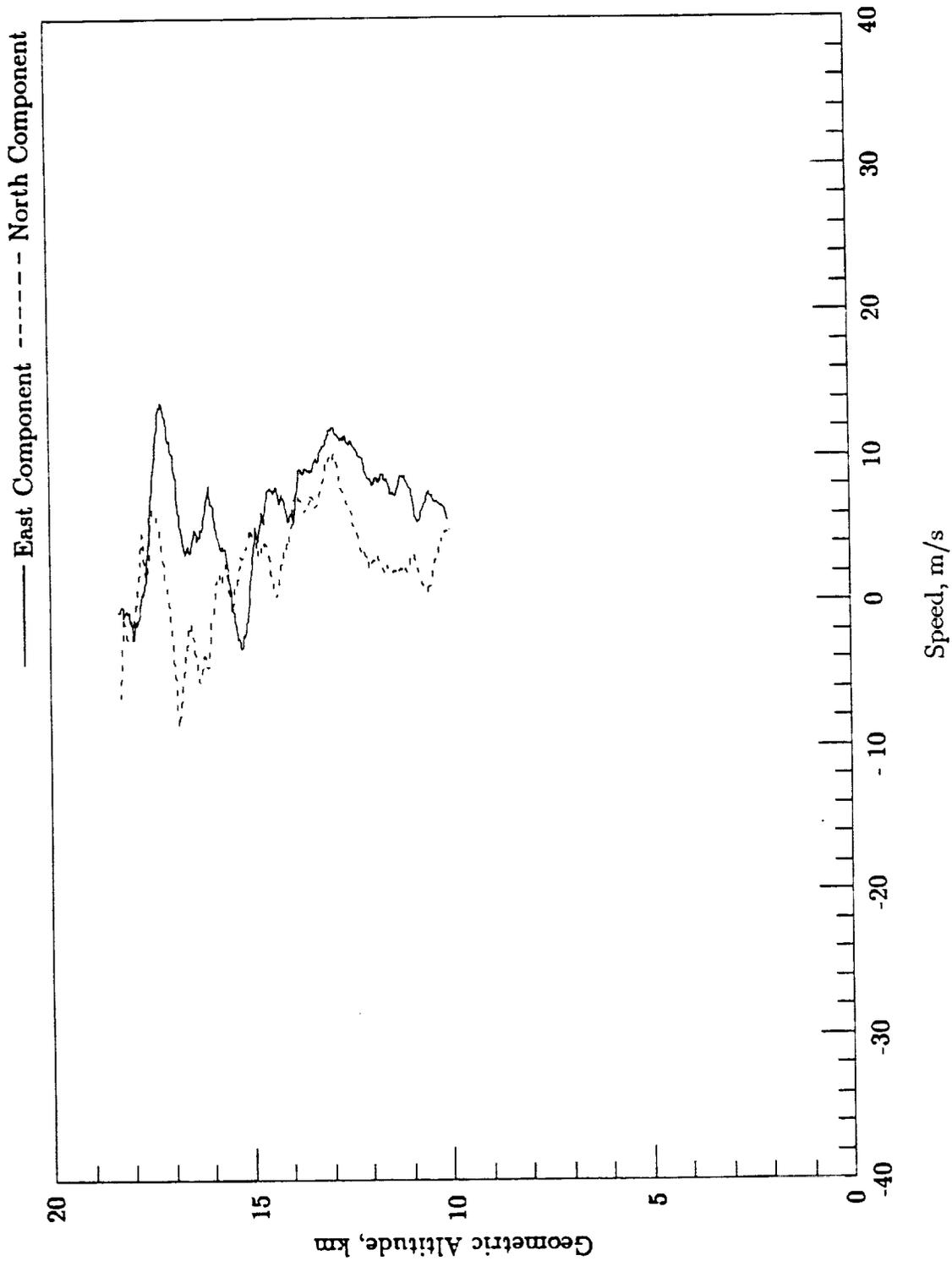


Figure 3.65 Wind velocity horizontal components from F-104 data, Climb # 2, 20-May-89, Dryden Flight Research Facility, radar ground speed.

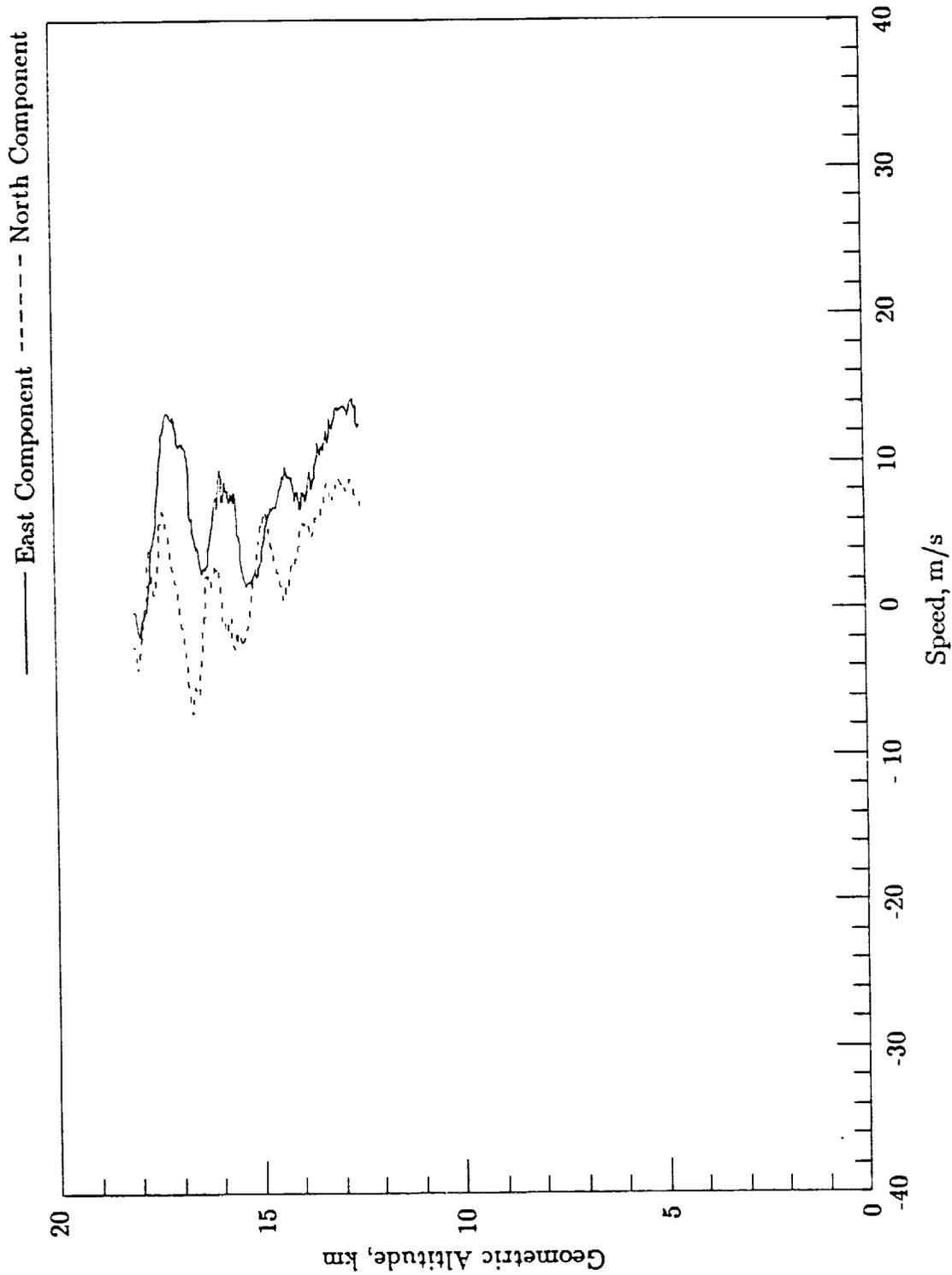


Figure 3.66 Wind velocity horizontal components from F-104 data, Descent # 1, 20-Jul-89, Dryden Flight Research Facility, INS ground speed.

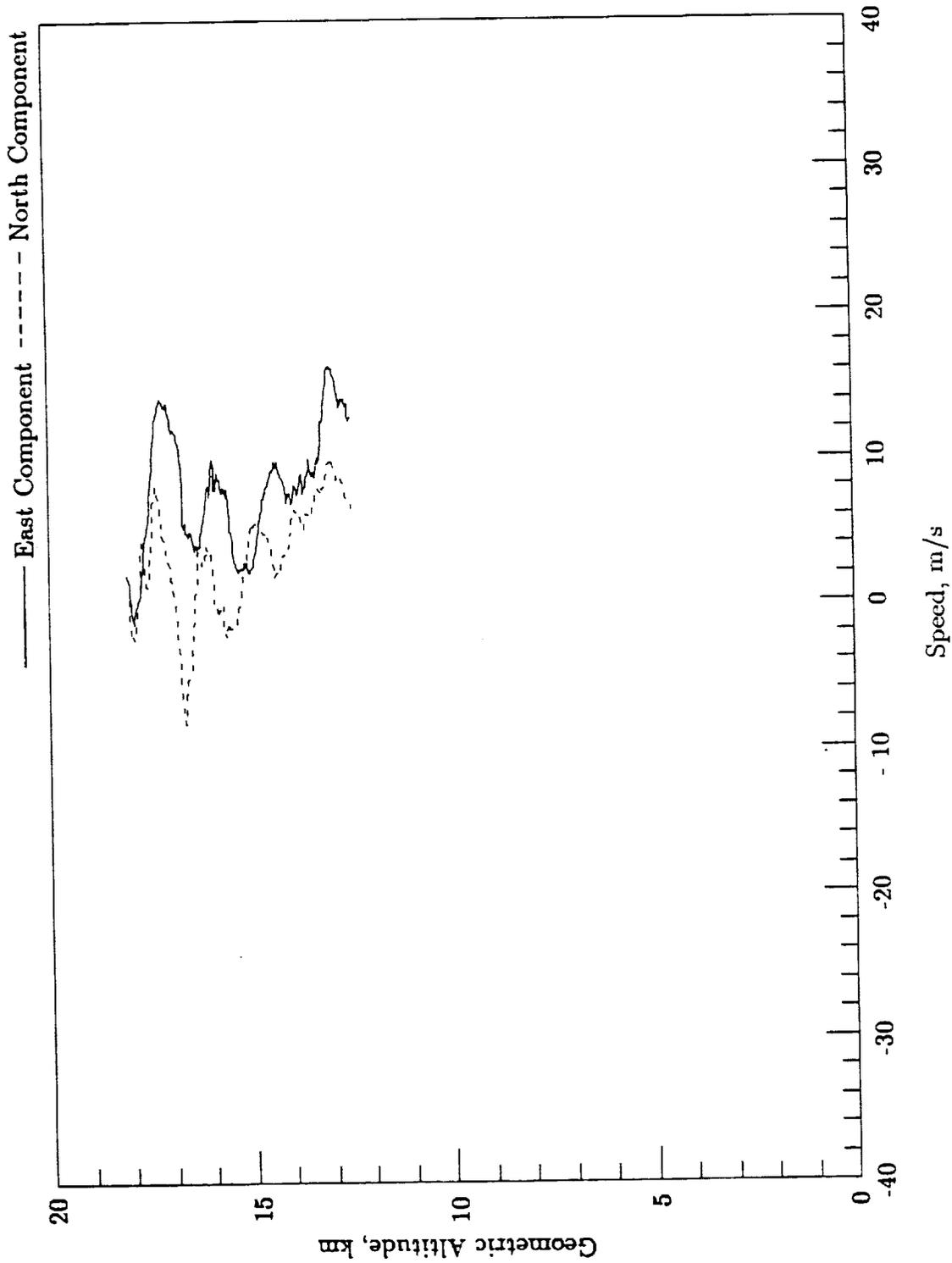


Figure 3.67 Wind velocity horizontal components from F-104 data, Descent # 1, 20-Jul-89, Dryden Flight Research Facility, radar ground speed.

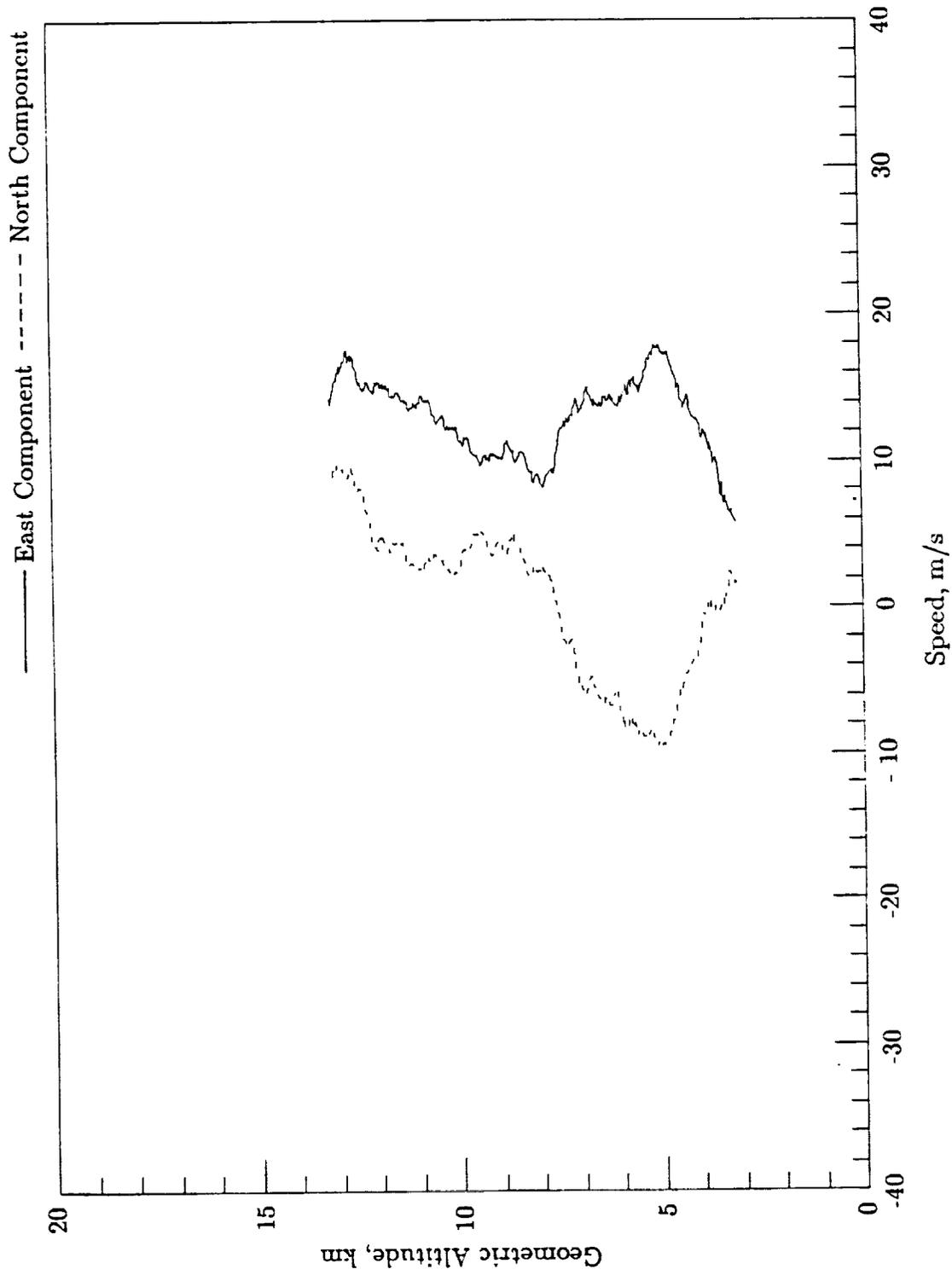


Figure 3.68 Wind velocity horizontal components from F-104 data, Descent # 2, 20-Jul-89, Dryden Flight Research Facility, INS ground speed.

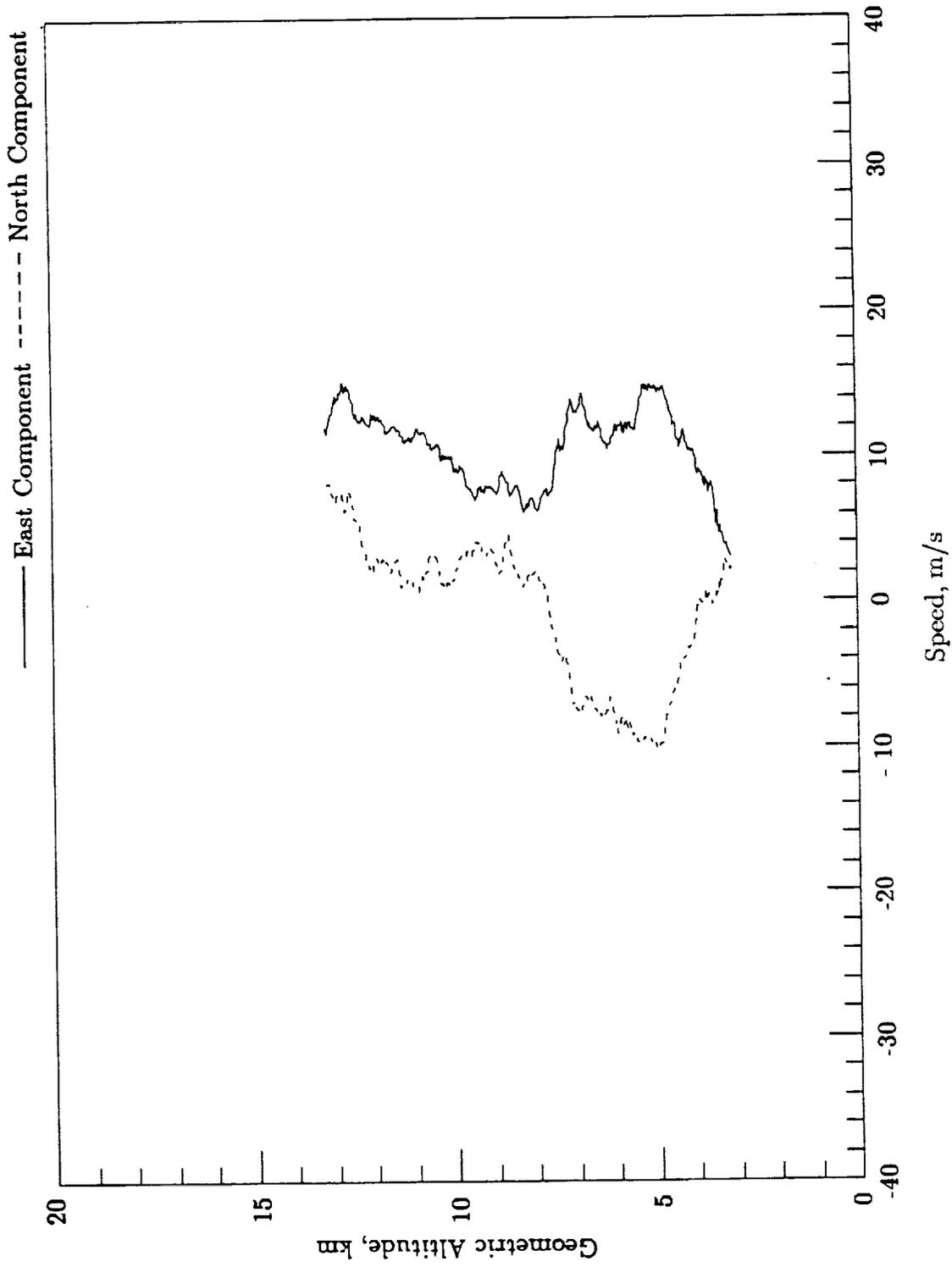
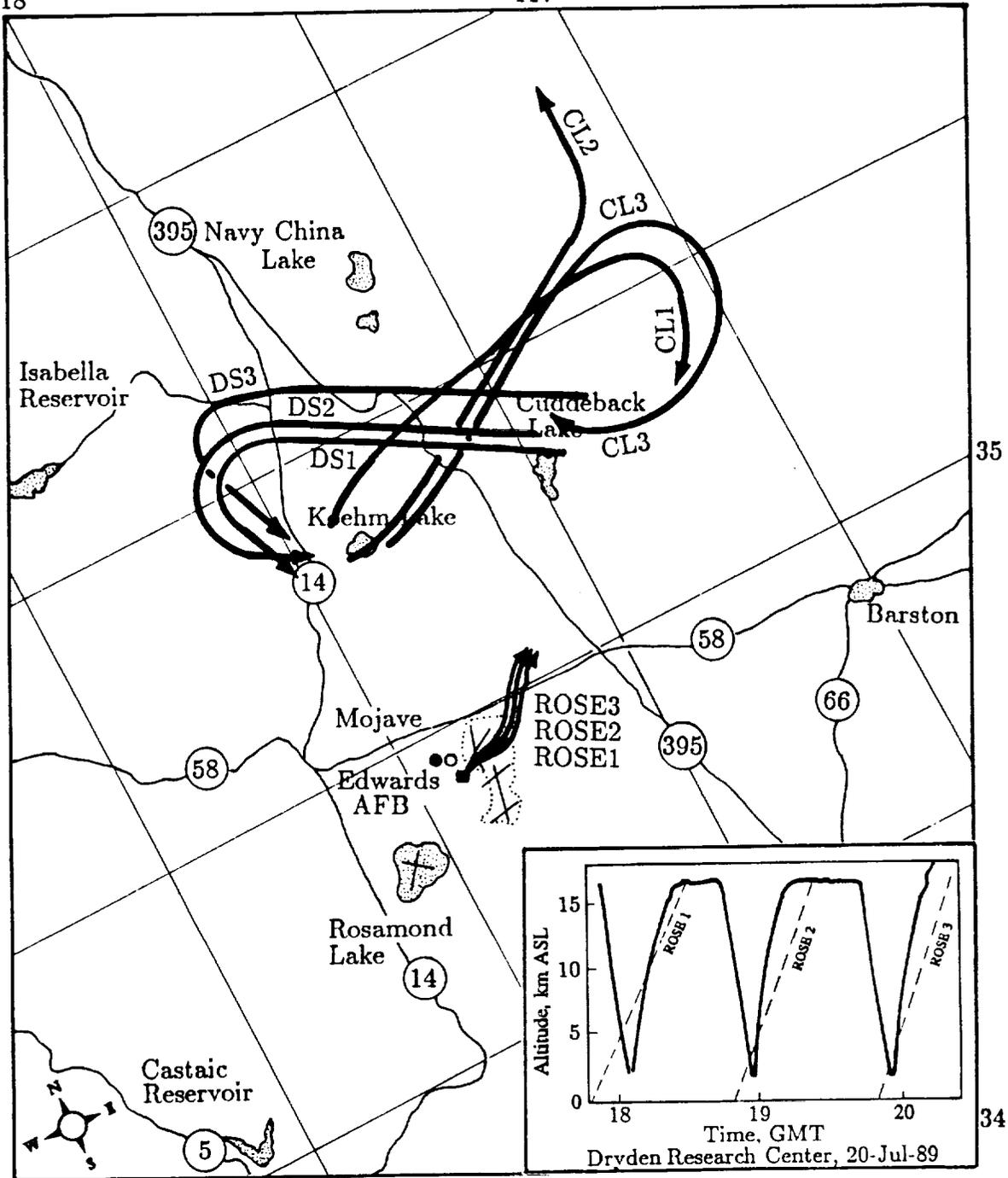


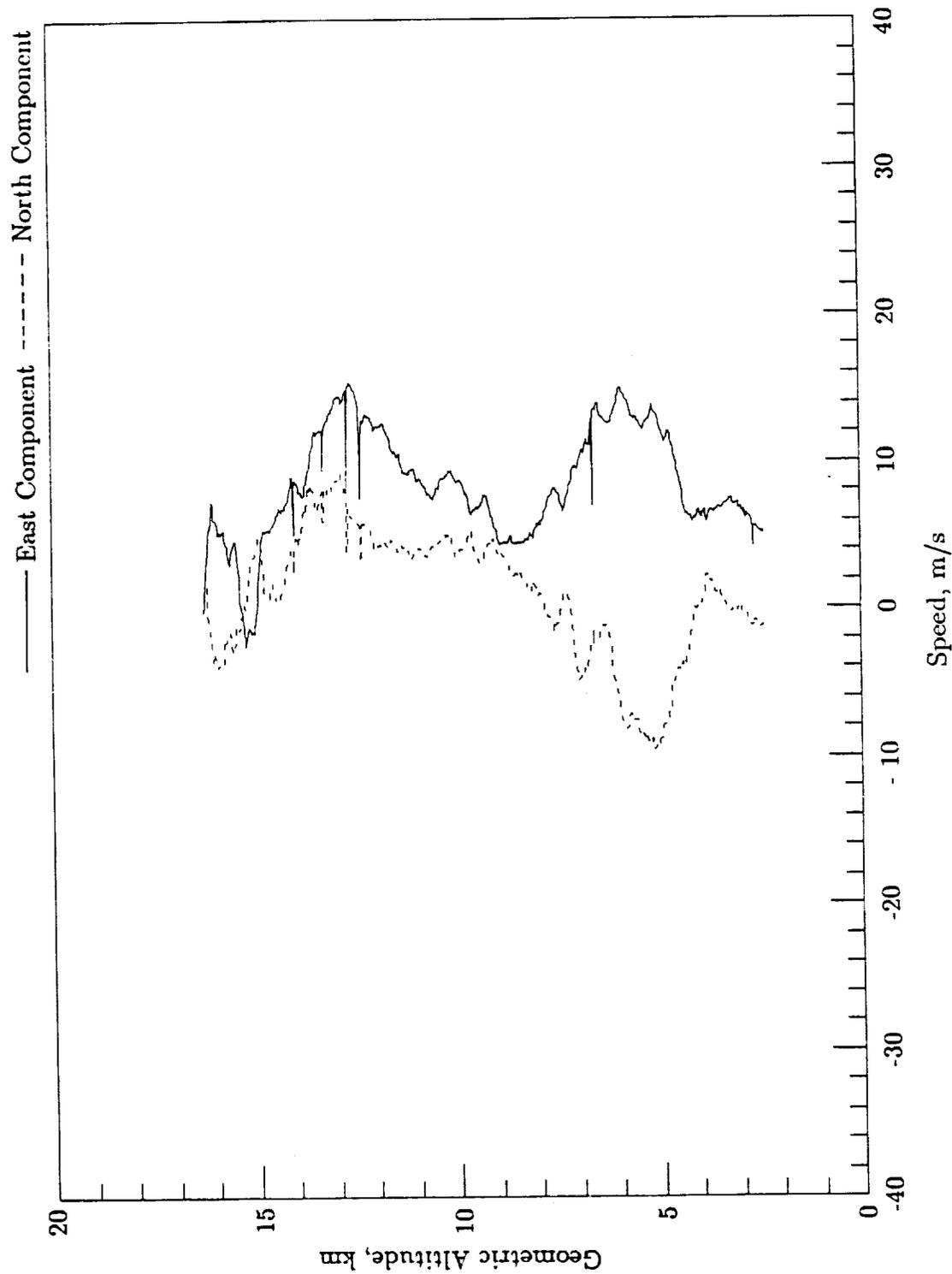
Figure 3.69 Wind velocity horizontal components from F-104 data, Descent # 2, 20-Jul-89, Dryden Flight Research Facility, radar ground speed.

C-2



- Jimsphere/Windsonde/Rawinsonde Release Station, 2300
- FPS -16 38 & 41 2700
- FPS -16 34 & RADAR #5

Figure 3.70 Flight 1286 Jimsphere and ER-2 paths.



**Figure 3.71** Wind velocity horizontal from ER-2 data, Descent # 1, 20-Jul-89, Dryden Flight Research Facility, INS ground speed.

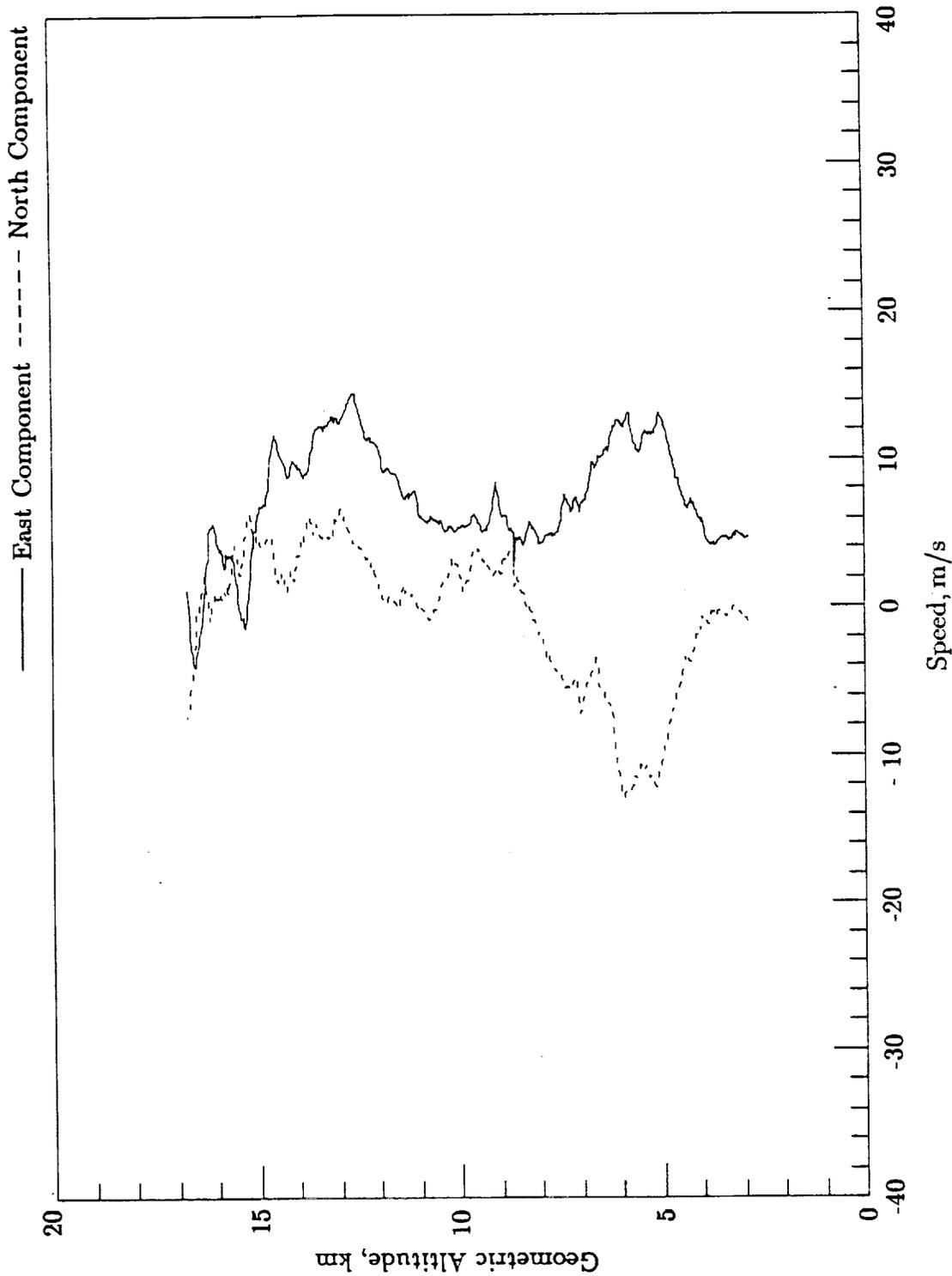


Figure 3.72 Wind velocity horizontal from ER-2 data, Climb # 1, 20-Jul-89, Dryden Flight Research Facility, INS ground speed.

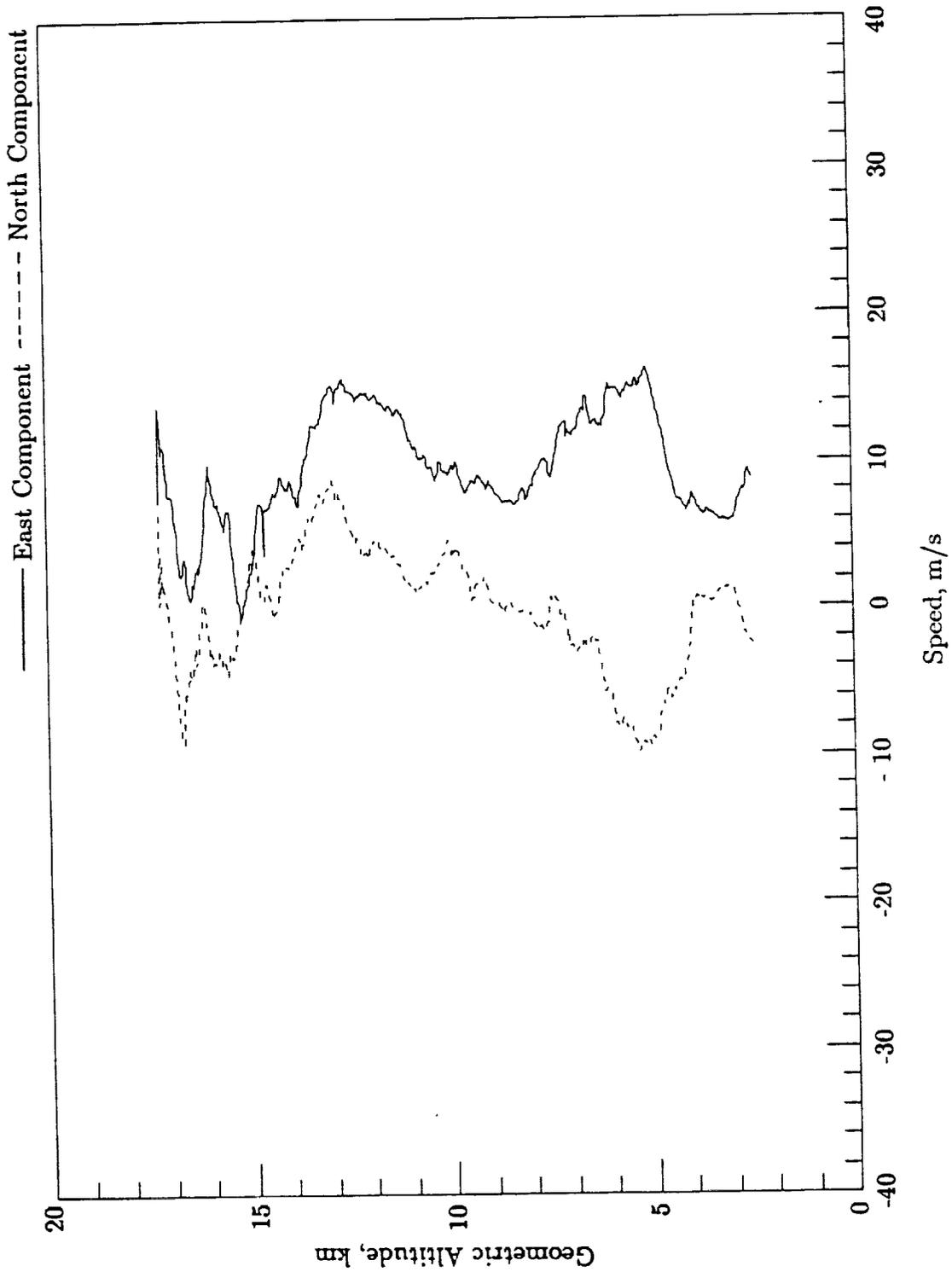


Figure 3.73 Wind velocity horizontal from ER-2 data, Descent # 2, 20-Jul-89, Dryden Flight Research Facility, INS ground speed.

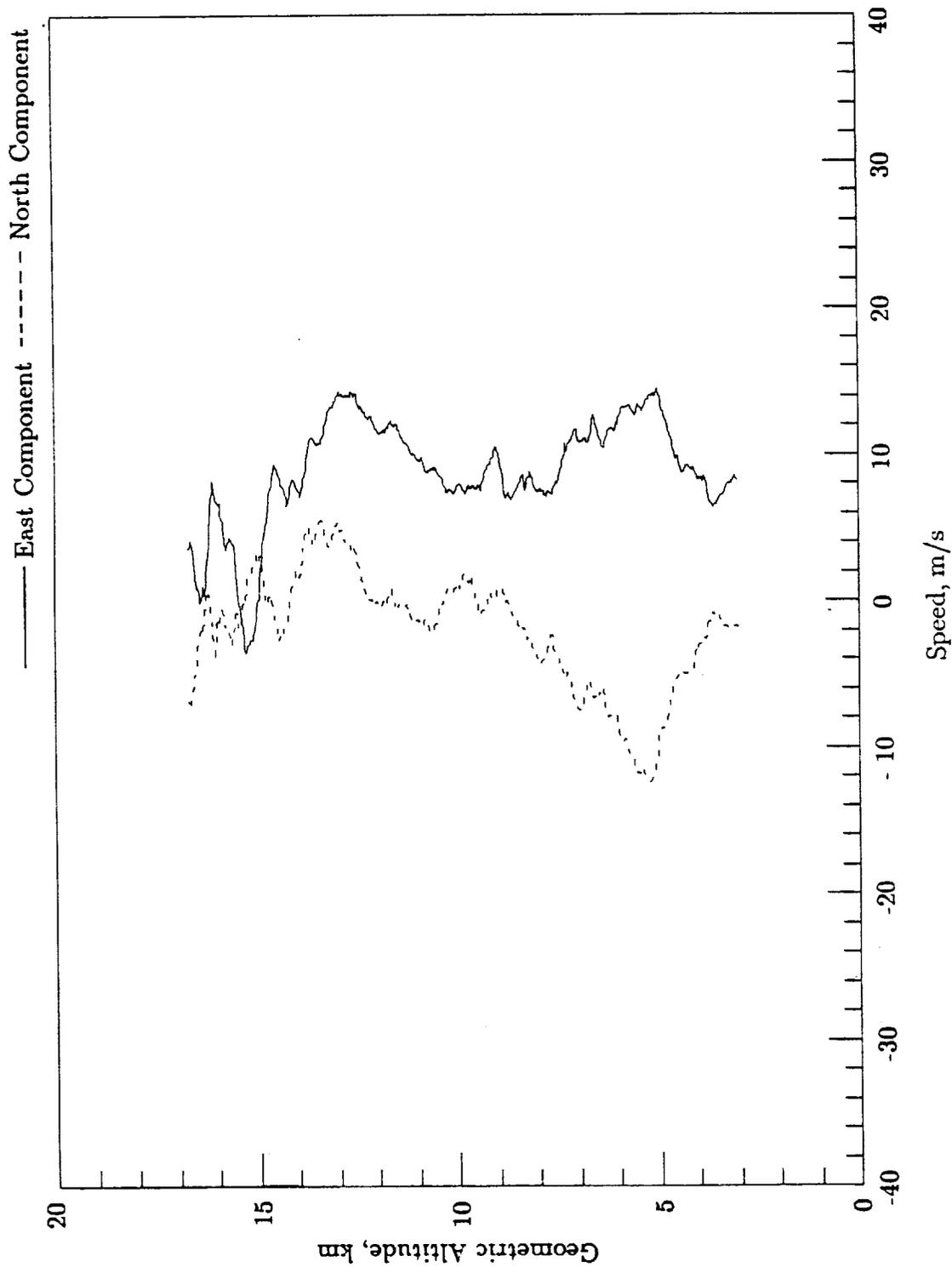


Figure 3.74 Wind velocity horizontal from ER-2 data, Climb # 2, 20-Jul-89, Dryden Flight Research Facility, INS ground speed.

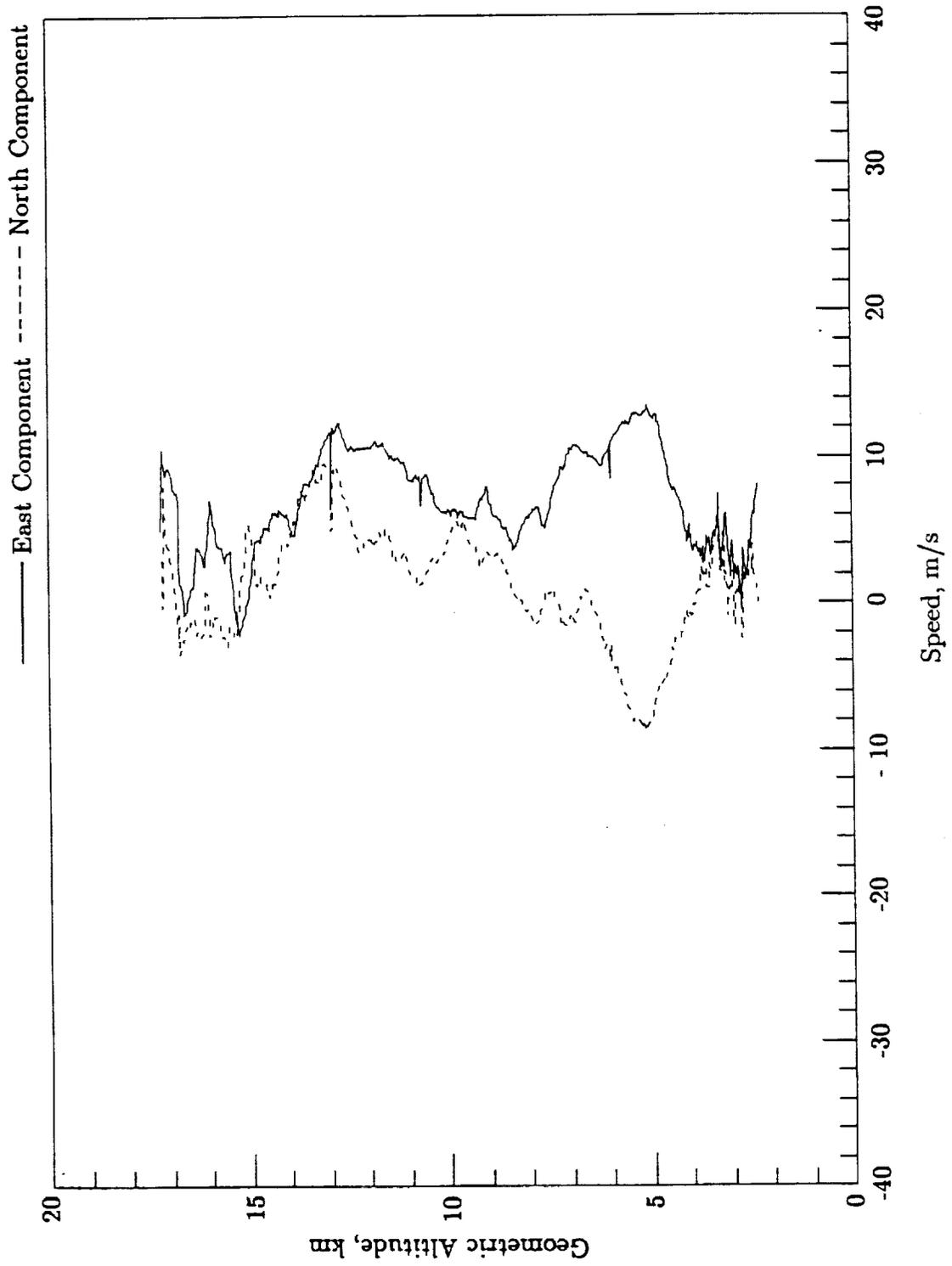


Figure 3.75 Wind velocity horizontal from ER-2 data, Descent # 3, 20-Jul-89, Dryden Flight Research Facility, INS ground speed.

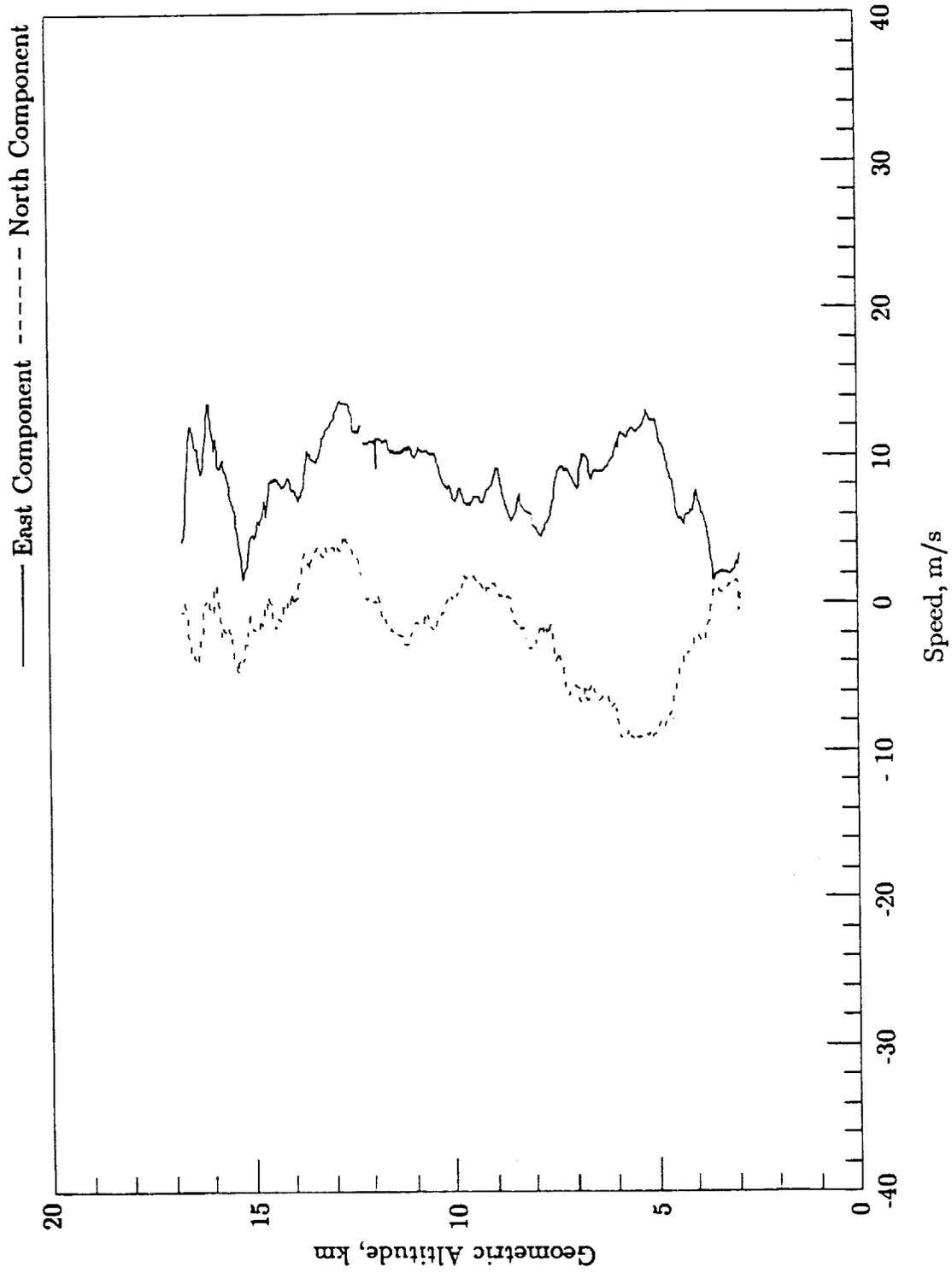


Figure 3.76 Wind velocity horizontal from ER-2 data, Climb # 3, 20-Jul-89, Dryden Flight Research Facility, INS ground speed.

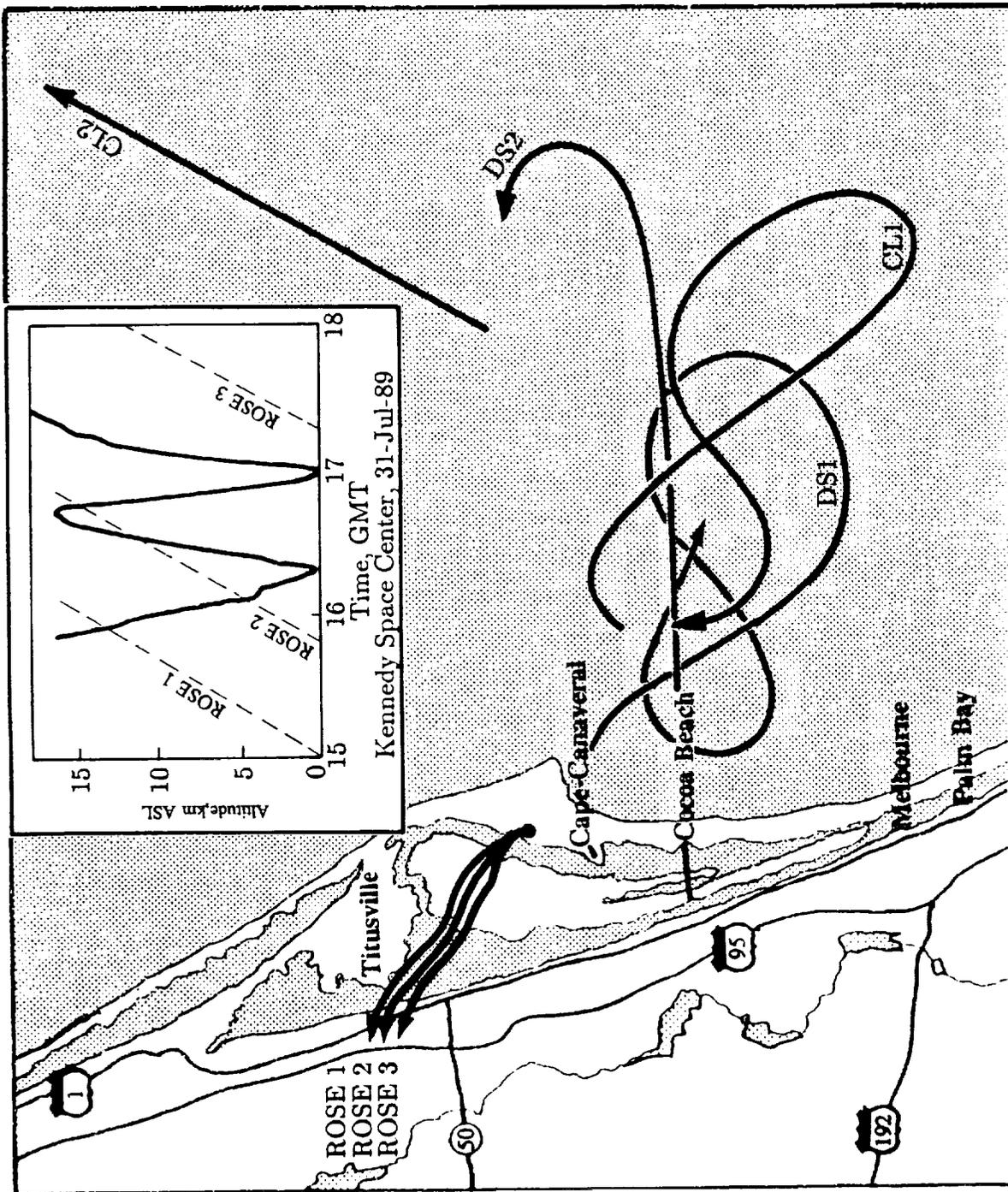


Figure 3.77 Jimsphere and ER-2 paths © KSC, 31-Jul-89.

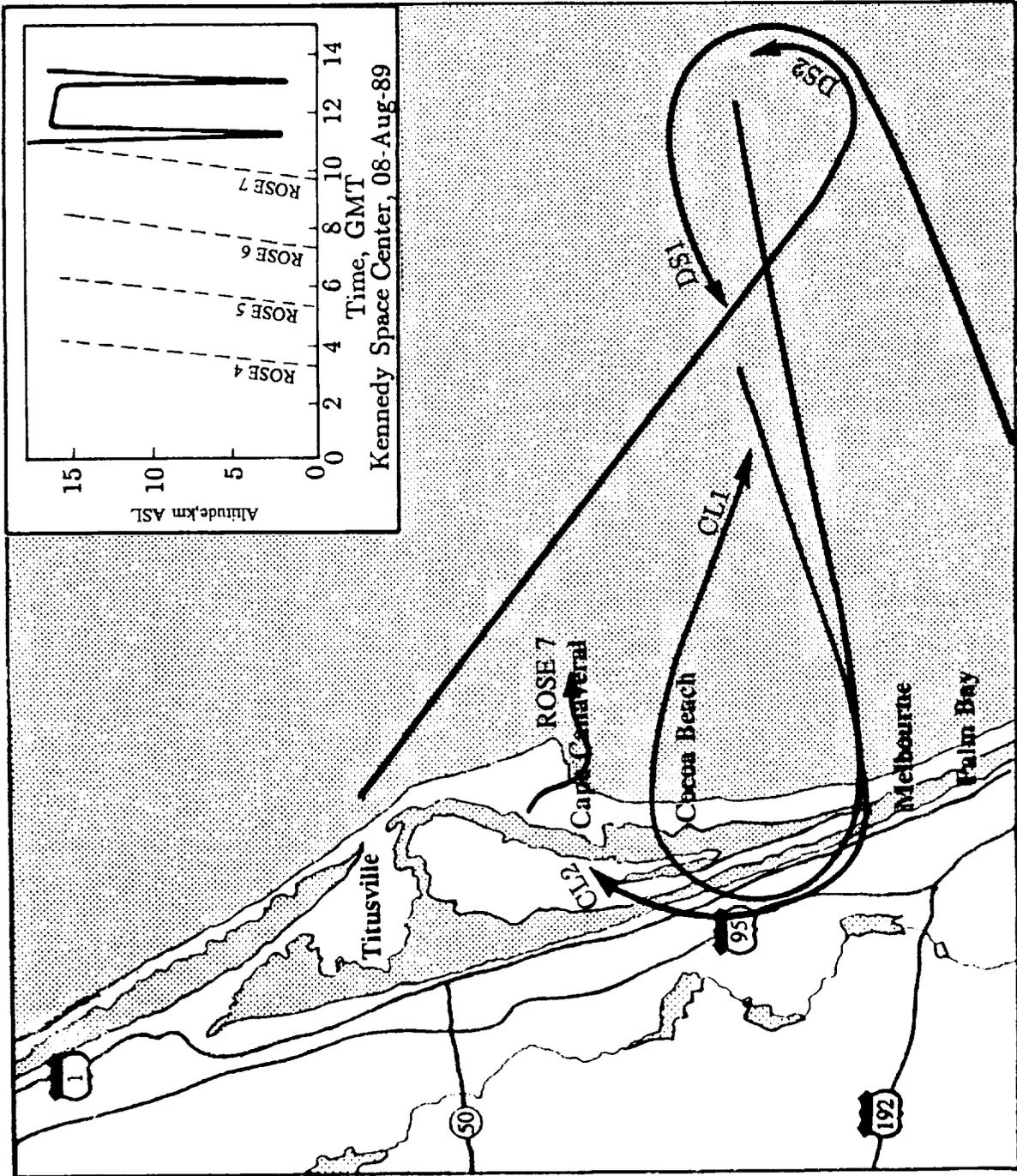
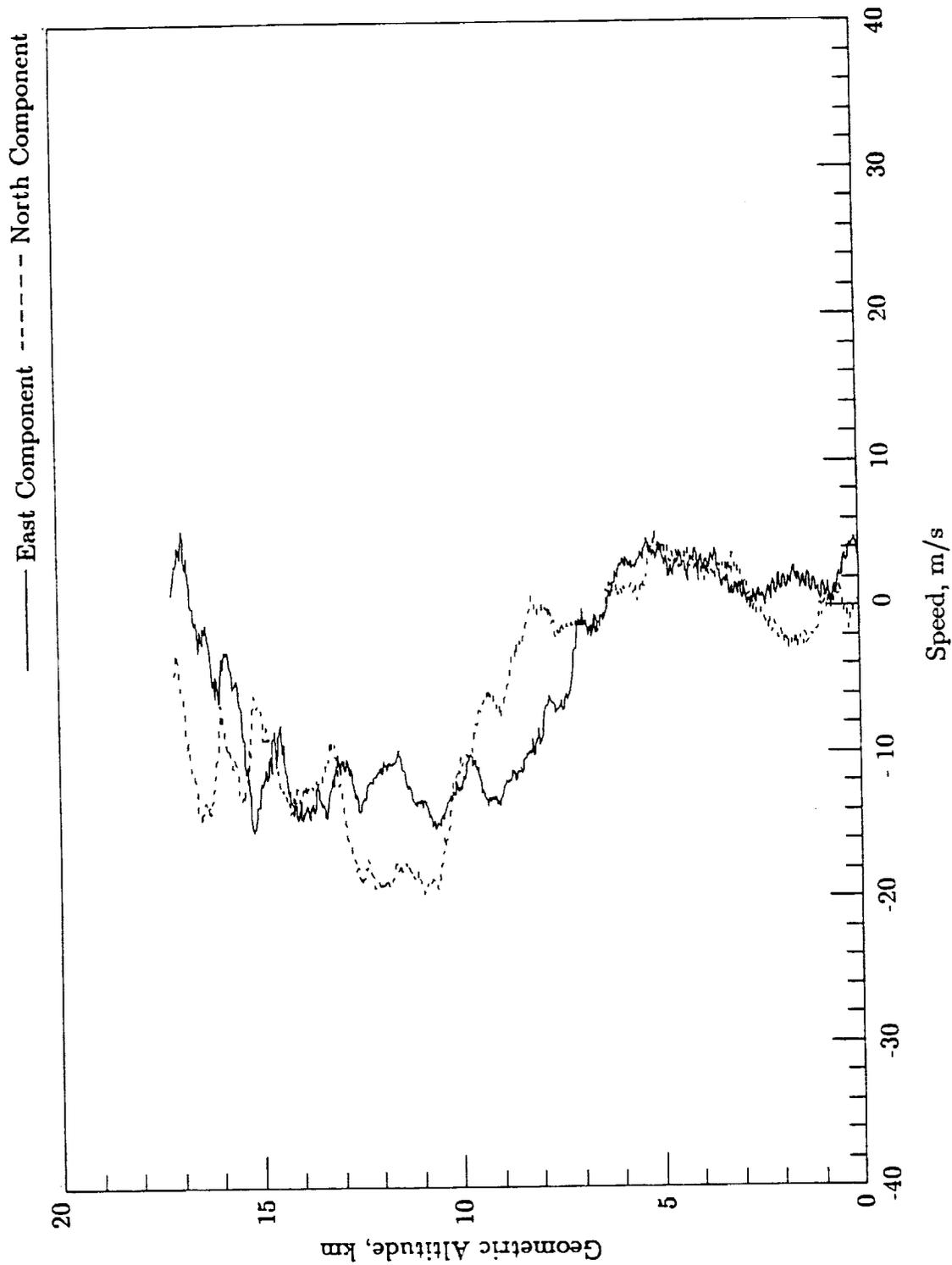


Figure 3.78 Jimsphere and ER-2 paths @ KSC, 08-Aug-89.



**Figure 3.79** Wind velocity horizontal components from Jimsphere  
Release # 1, 31-Jul-89, Kennedy Space Center.

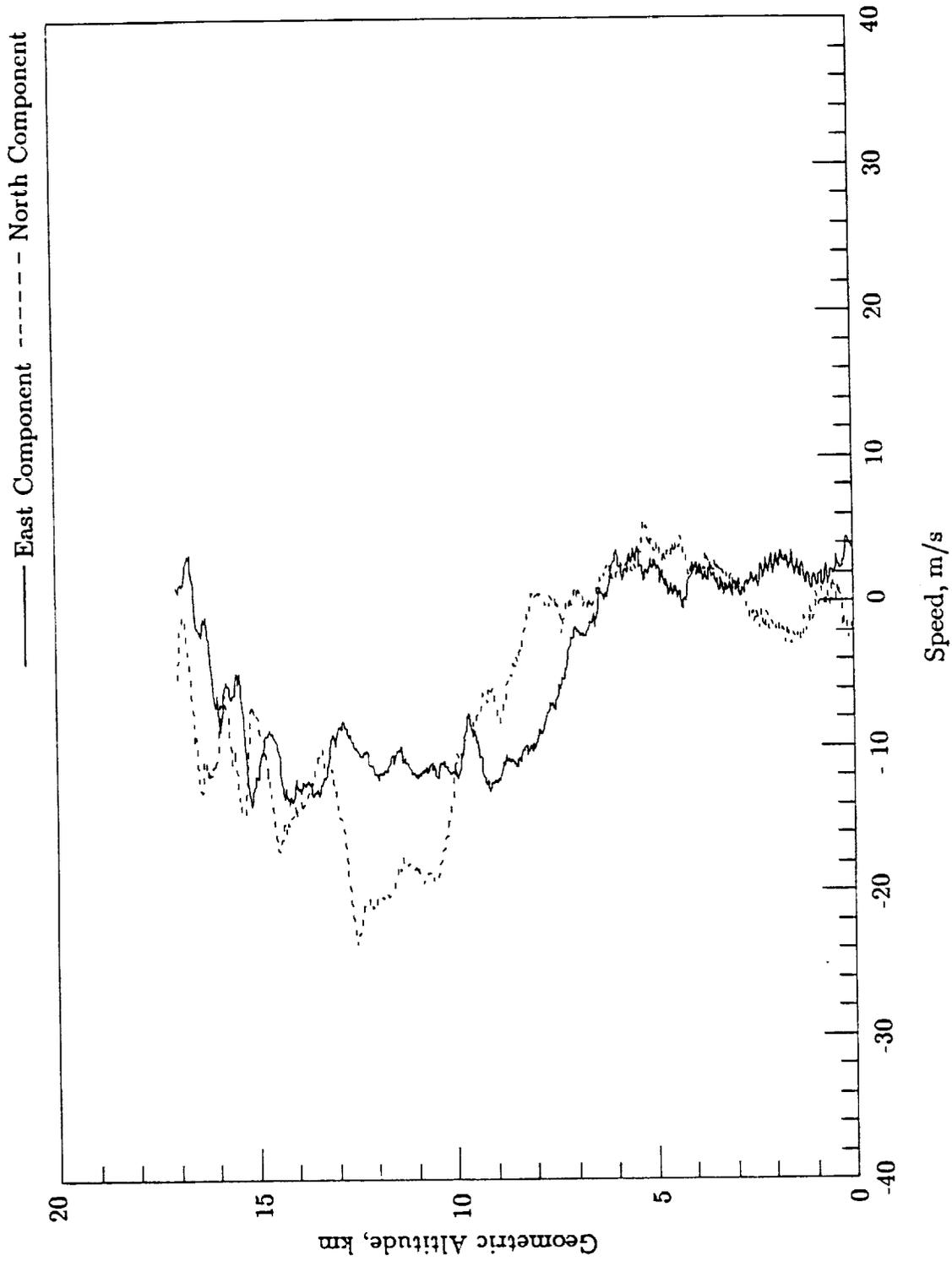


Figure 3.80 Wind velocity horizontal components from Jimsphere Release # 2, 31-Jul-89, Kennedy Space Center.

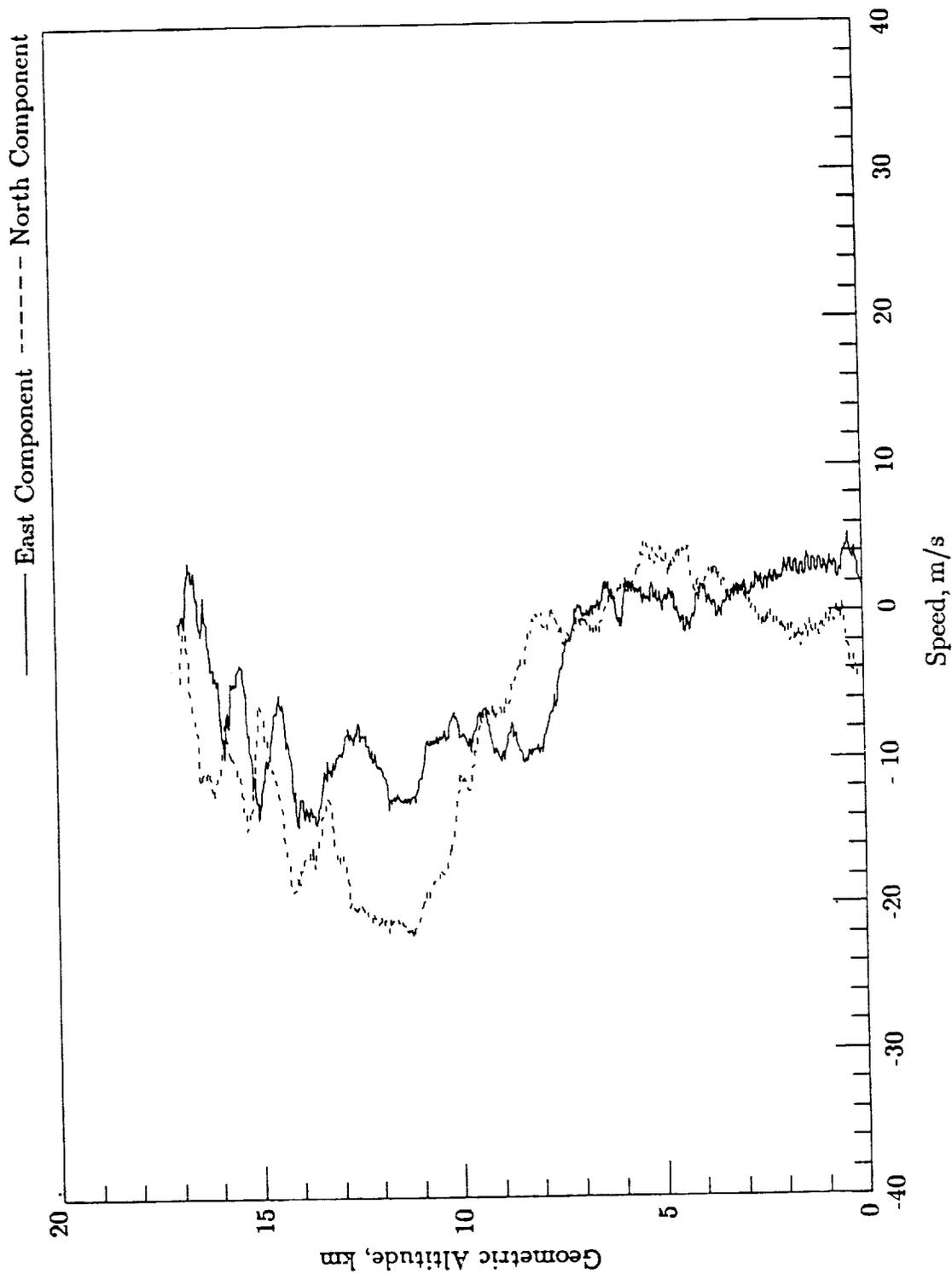


Figure 3.81 Wind velocity horizontal components from Jimsphere Release # 3, 31-Jul-89, Kennedy Space Center.

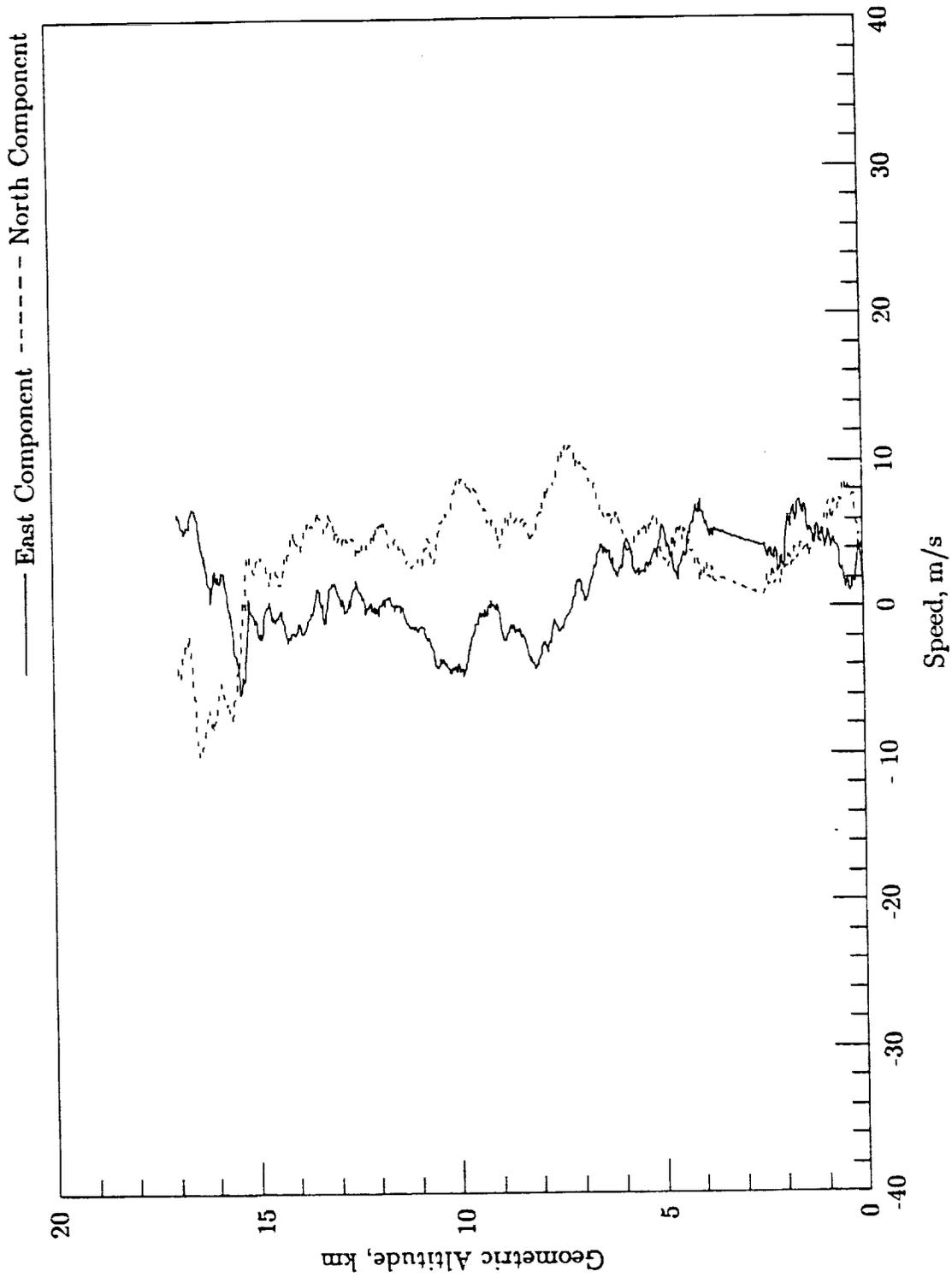
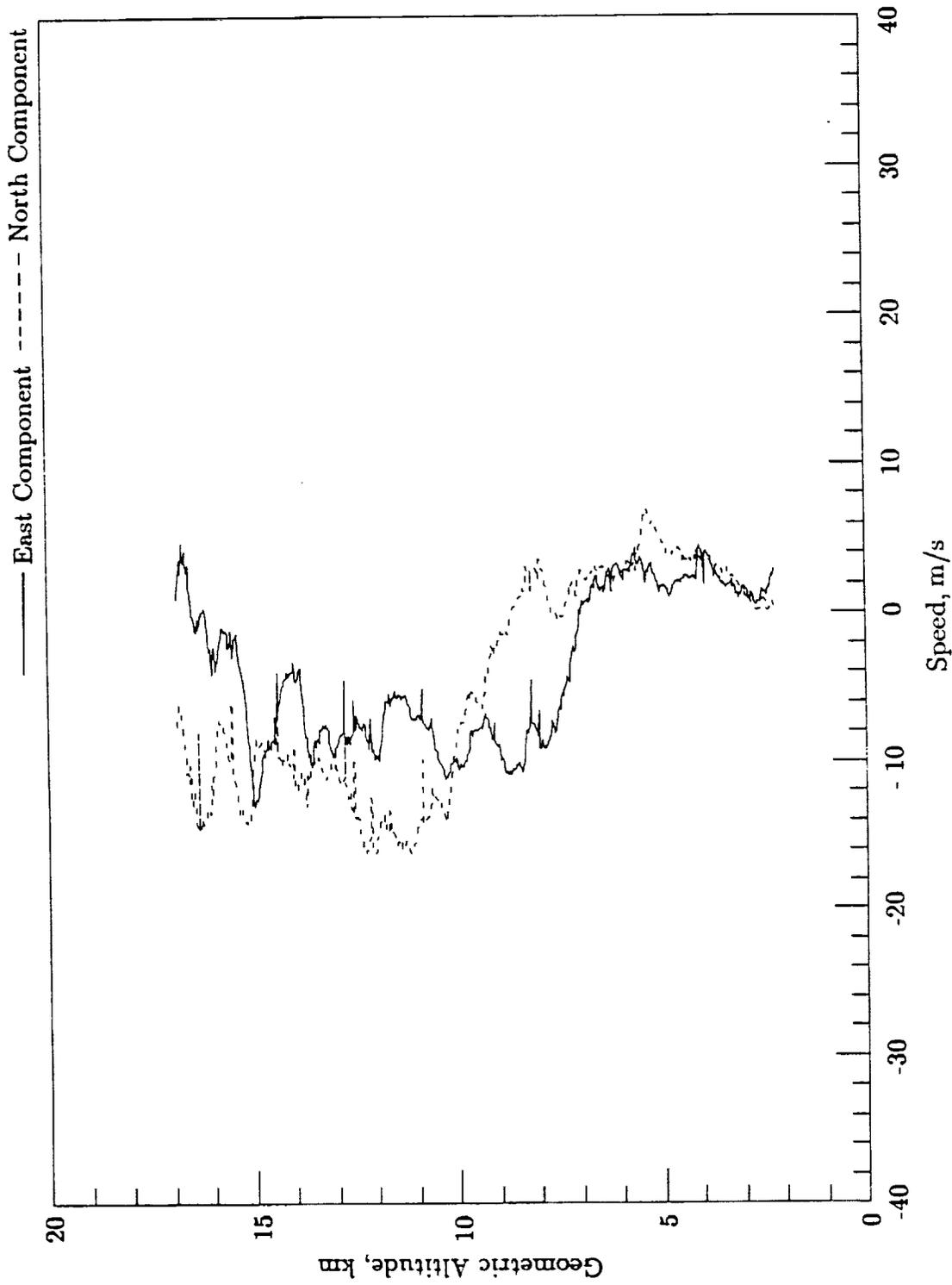
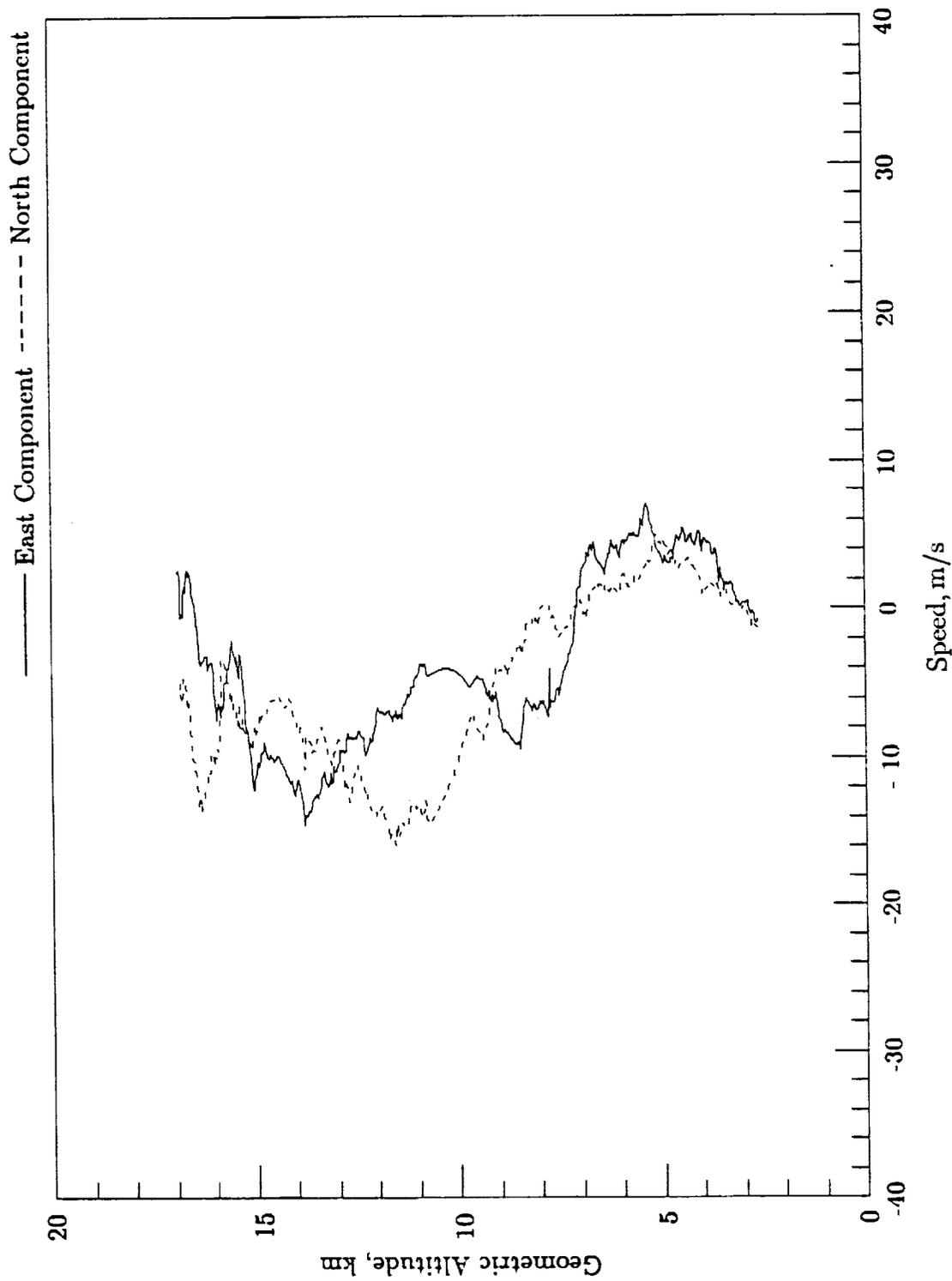


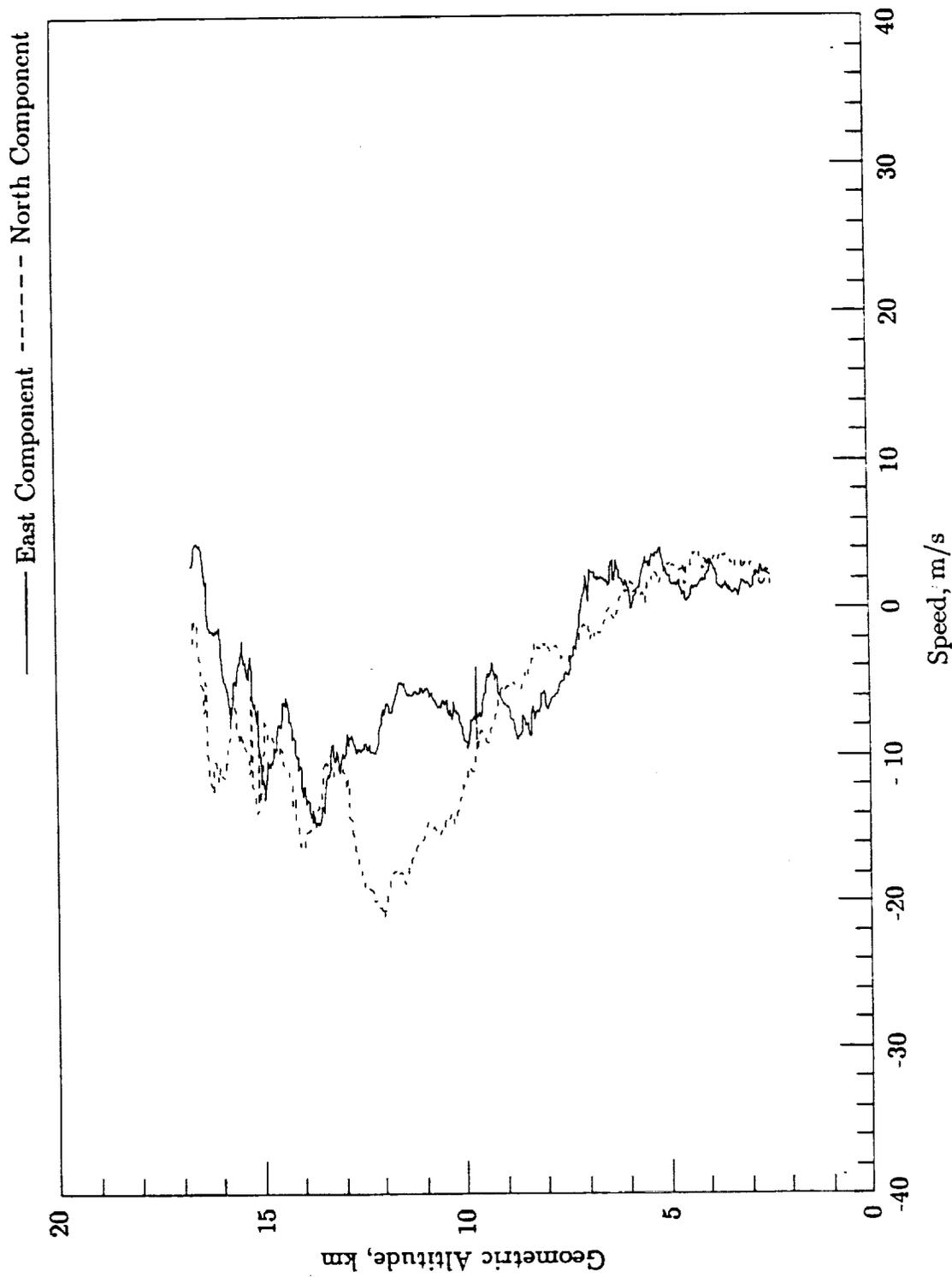
Figure 3.82 Wind velocity horizontal components from Jimsphere  
Release # 7, 08-Aug-89, Kennedy Space Center.



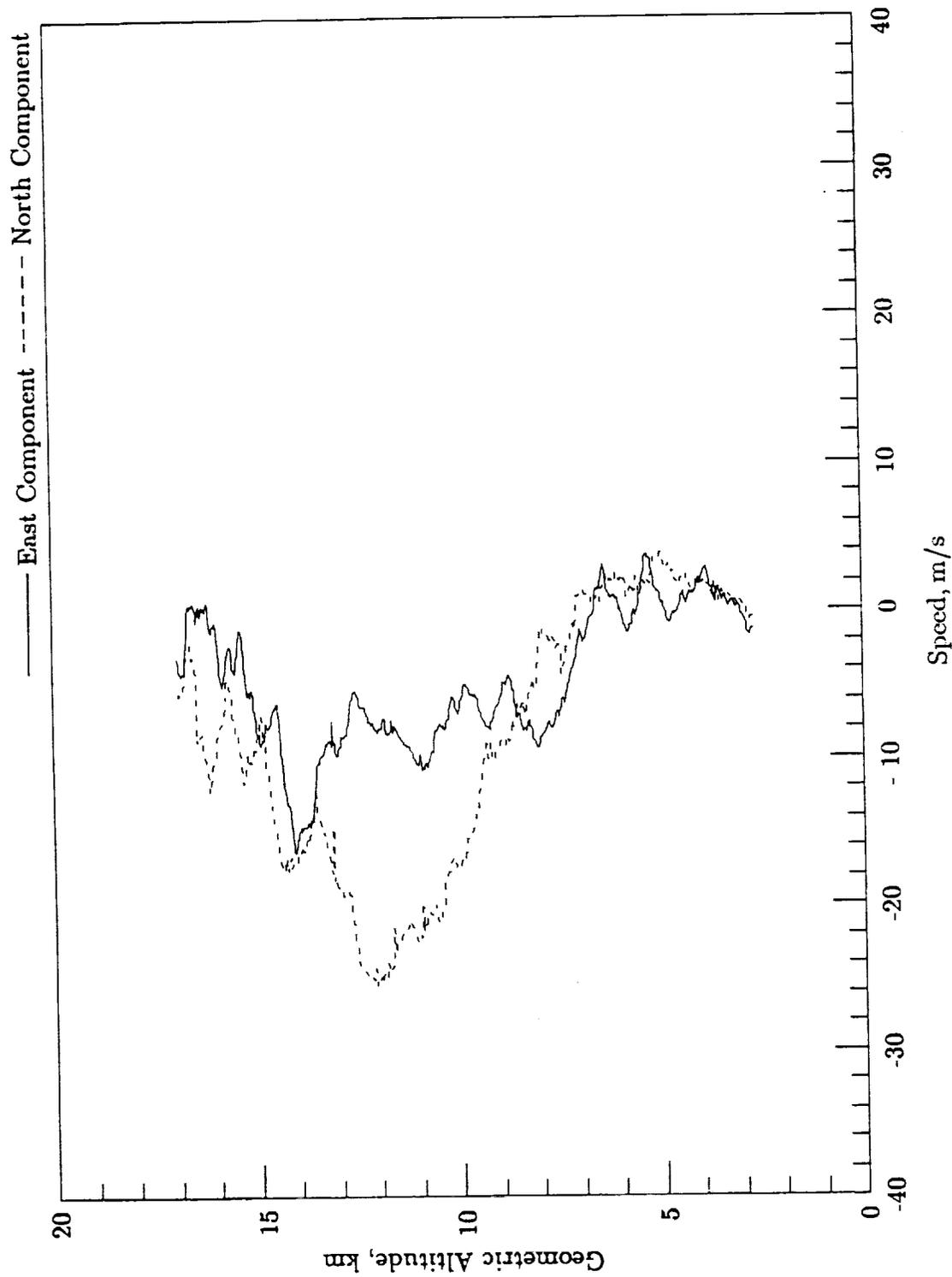
**Figure 3.83** Wind velocity horizontal components from ER-2 data, Descent # 1, 31-Jul-89, Kennedy Space Center, INS ground speed.



**Figure 3.84** Wind velocity horizontal components from ER-2 data, Climb # 1, 31-Jul-89, Kennedy Space Center, INS ground speed.



**Figure 3.85** Wind velocity horizontal components from ER-2 data, Descent # 2, 31-Jul-89, Kennedy Space Center, INS ground speed.



**Figure 3.86** Wind velocity horizontal components from ER-2 data, Climb # 2, 31-Jul-89, Kennedy Space Center, INS ground speed.

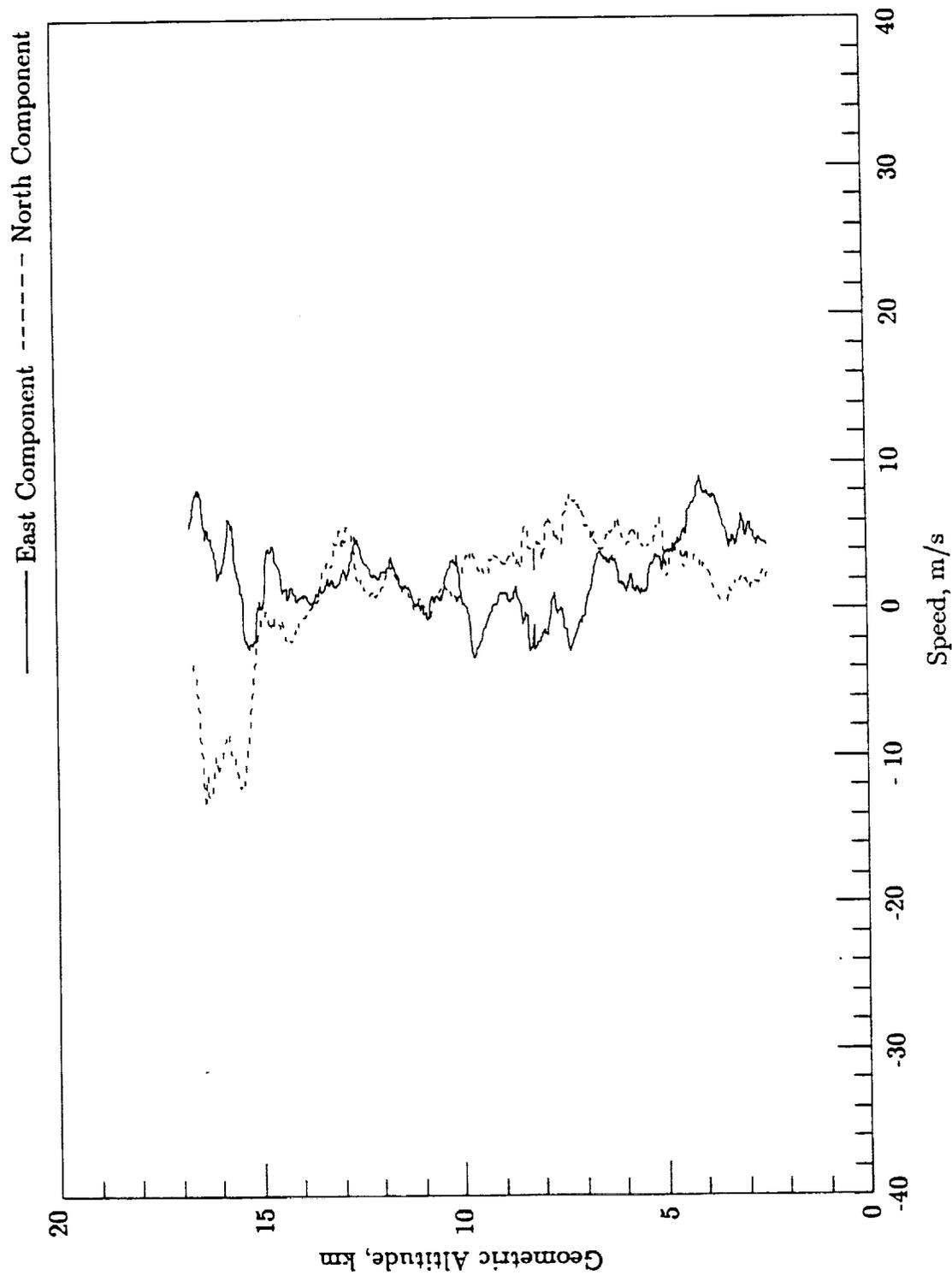


Figure 3.87 Wind velocity horizontal components from ER-2 data, Descent # 1, 08-Aug-89, Kennedy Space Center, INS ground speed.

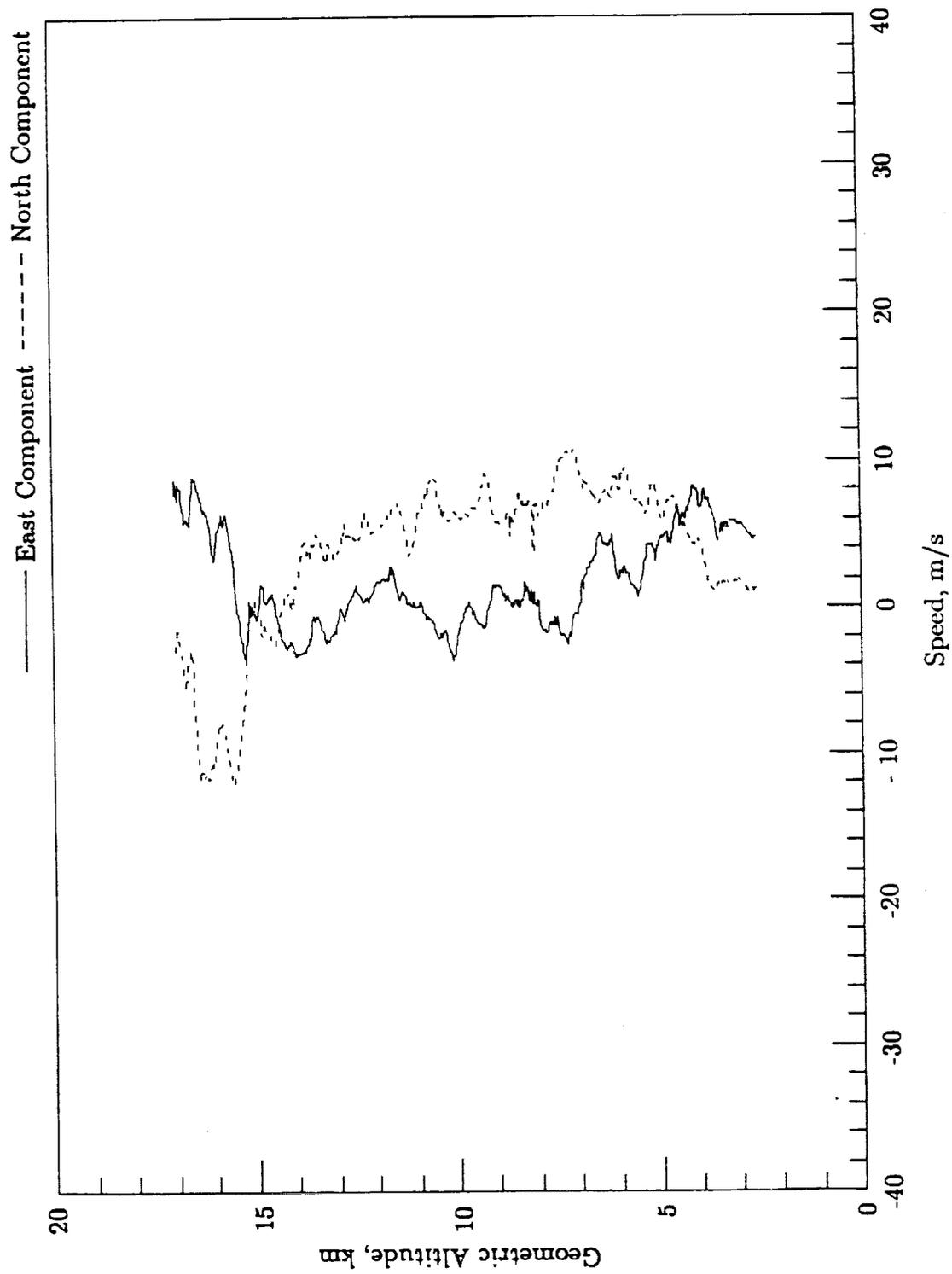
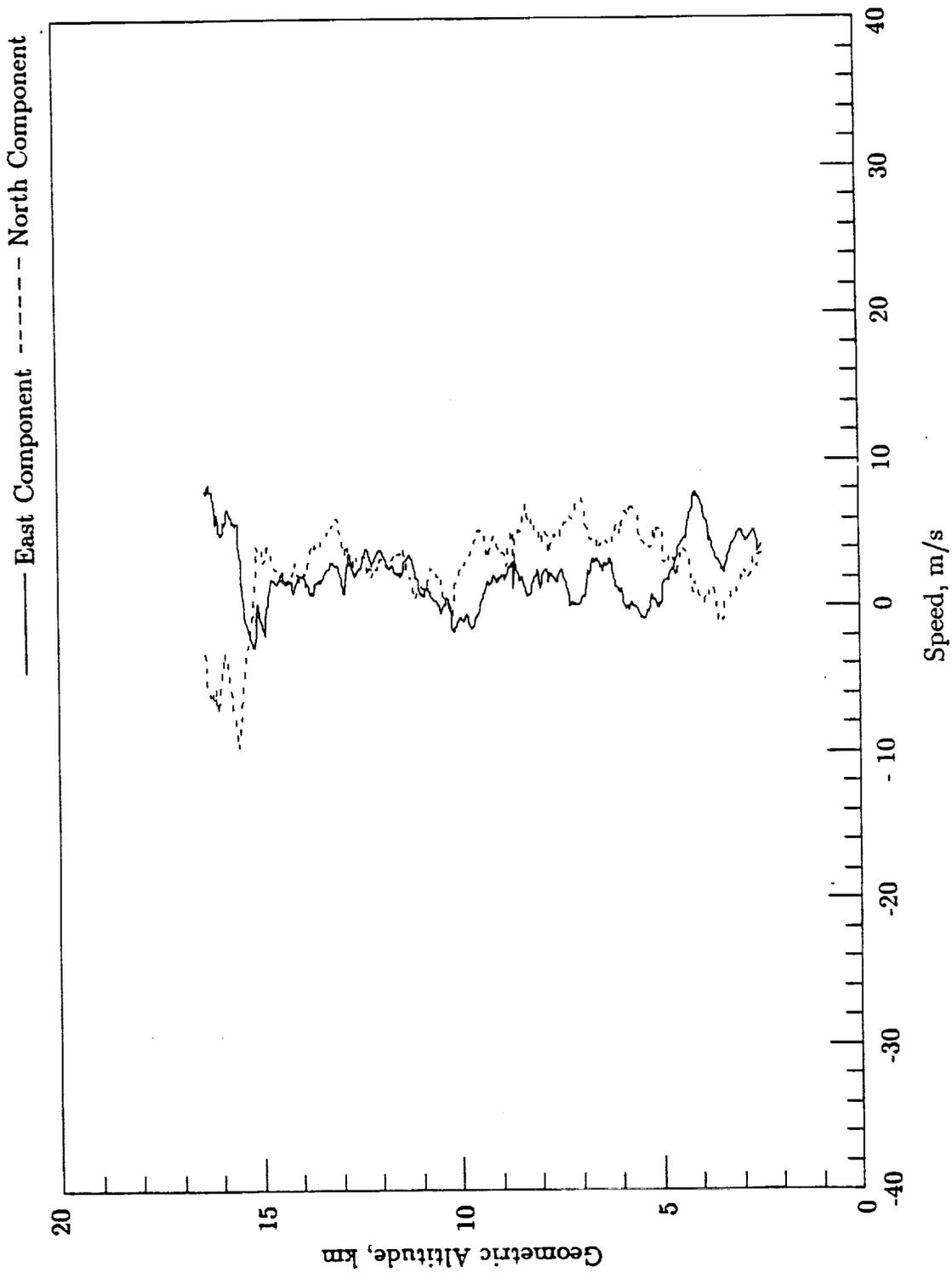
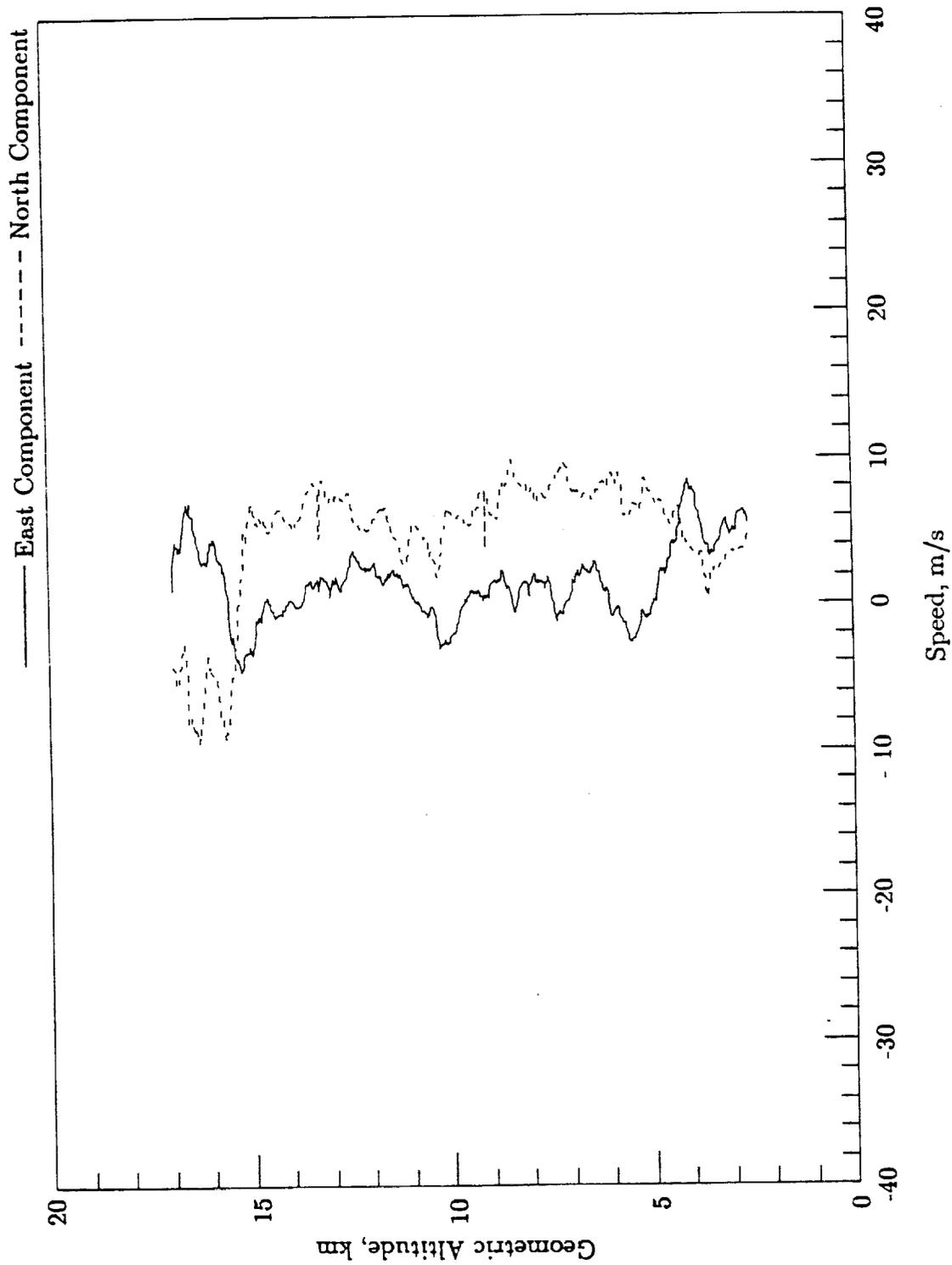


Figure 3.88 Wind velocity horizontal components from ER-2 data, Climb # 1, 08-Aug-89, Kennedy Space Center, INS ground speed.



**Figure 3.89** Wind velocity horizontal components from ER-2 data, Descent # 2, 08-Aug-89, Kennedy Space Center, INS ground speed.



**Figure 3.90** Wind velocity horizontal components from ER-2 data, Climb # 2, 08-Aug-89, Kennedy Space Center, INS ground speed.

**Table 3.1 Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1231, 22-Jun-88, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = 1.1 m/s  
Average heading difference = 0.3 deg

Average magnitude difference = 1.7 m/s  
Average heading difference = -4.3 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	2.2	6.1	2.5	1.7	3 - 6	2.4	9.3	2.1	3.4		
6 - 9	1.5	4.7	2.0	1.9	6 - 9	2.1	3.5	1.8	1.9		
9 - 12	4.1	4.6	4.0	2.9	9 - 12	1.1	2.8	0.8	1.7		
12 - 15	2.6	4.5	2.6	2.3	12 - 15	N/A	N/A	N/A	N/A		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	2.8	5.1	2.9	2.3	Total Profile	2.1	6.3	1.8	2.6		

Average magnitude difference = 0.7 m/s  
Average heading difference = 7.7 deg

Climb #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)
0 - 3	N/A	N/A	N/A	N/A	0 - 3
3 - 6	N/A	N/A	N/A	N/A	3 - 6
6 - 9	N/A	N/A	N/A	N/A	6 - 9
9 - 12	2.8	4.9	4.9	3.1	9 - 12
12 - 15	1.8	10.9	1.5	5.6	12 - 15
15 - 18	N/A	N/A	N/A	N/A	15 - 18
Total Profile	2.3	8.7	2.3	4.6	Total Profile

**Table 3.2 Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1231, 22-Jun-88, radar ground speed, Dryden Flight Research Facility**

Average magnitude difference = 2.2 m/s  
Average heading difference = -0.7 deg

Average magnitude difference = 1.7 m/s  
Average heading difference = -0.9 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	2.1	6.6	2.3	2.3	3 - 6	2.5	6.3	2.3	2.3		
6 - 9	2.6	5.5	3.0	2.3	6 - 9	2.1	3.1	2.1	1.3		
9 - 12	5.8	5.0	5.8	3.0	9 - 12	1.1	2.5	1.2	1.3		
12 - 15	3.2	6.8	3.2	3.4	12 - 15	N/A	N/A	N/A	N/A		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	3.8	5.9	3.9	2.7	Total Profile	2.1	4.5	2.1	1.8		

Average magnitude difference = 3.2 m/s  
Average heading difference = 7.1 deg

Climb #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)
0 - 3	N/A	N/A	N/A	N/A	0 - 3
3 - 6	N/A	N/A	N/A	N/A	3 - 6
6 - 9	N/A	N/A	N/A	N/A	6 - 9
9 - 12	4.4	2.7	4.3	1.7	9 - 12
12 - 15	3.4	18.9	5.3	7.4	12 - 15
15 - 18	N/A	N/A	N/A	N/A	15 - 18
Total Profile	3.9	14.2	4.9	5.7	Total Profile

**Table 3.3 Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1232, 20-Jul-88, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = -0.9 m/s  
Average heading difference = -6.2 deg

Average magnitude difference = 2.0 m/s  
Average heading difference = -26.9 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	1.8	21.7	0.8	2.2	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	3.1	19.3	3.5	2.7	3 - 6	N/A	N/A	N/A	N/A		
6 - 9	3.5	15.1	2.3	3.8	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	2.5	13.8	2.3	2.9	9 - 12	2.8	28.9	2.2	3.3		
12 - 15	N/A	N/A	N/A	N/A	12 - 15	N/A	N/A	N/A	N/A		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	3.0	17.9	2.7	3.1	Total Profile	2.8	28.9	2.2	3.3		

Average magnitude difference = 0.5 m/s  
Average heading difference = 0.0 deg

Average magnitude difference = 3.7 m/s  
Average heading difference = -12.6 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	3.1	13.8	1.0	3.0		
3 - 6	N/A	N/A	N/A	N/A	3 - 6	4.7	32.5	3.4	5.6		
6 - 9	N/A	N/A	N/A	N/A	6 - 9	3.8	17.2	2.2	3.7		
9 - 12	2.0	16.8	2.0	1.5	9 - 12	4.9	10.6	2.3	4.7		
12 - 15	2.1	81.6	2.7	2.3	12 - 15	N/A	N/A	N/A	N/A		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	2.0	66.0	2.4	2.1	Total Profile	4.3	24.9	2.7	4.7		

**Table 3.3 (cont'd) Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1232, 20-Jul-88, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = -0.7 m/s  
Average heading difference = 35.0 deg

Climb #3					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	
0 - 3	N/A	N/A	N/A	N/A	
3 - 6	N/A	N/A	N/A	N/A	
6 - 9	N/A	N/A	N/A	N/A	
9 - 12	2.0	8.9	1.8	0.3	
12 - 15	2.4	69.4	3.6	2.5	
15 - 18	2.4	42.8	4.6	1.8	
Total Profile	2.2	55.4	4.1	2.1	

**Table 3.4 Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1232, 20-Jul-88, radar ground speed, Dryden Flight Research Facility**

Average magnitude difference = -0.8 m/s  
Average heading difference = -5.2 deg

Average magnitude difference = 3.2 m/s  
Average heading difference = -47.2 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	1.2	18.3	1.0	1.4	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	3.2	19.3	3.4	2.8	3 - 6	N/A	N/A	N/A	N/A		
6 - 9	3.7	16.4	2.8	4.0	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	1.4	18.4	3.4	2.1	9 - 12	3.9	49.5	3.4	3.8		
12 - 15	N/A	N/A	N/A	N/A	12 - 15	N/A	N/A	N/A	N/A		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	3.1	18.1	2.9	3.1	Total Profile	3.9	49.5	3.4	3.8		

Average magnitude difference = 0.6 m/s  
Average heading difference = -6.7 deg

Average magnitude difference = -0.1 m/s  
Average heading difference = 31.4 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	1.5	11.7	0.7	1.7		
3 - 6	N/A	N/A	N/A	N/A	3 - 6	2.9	16.8	3.0	2.7		
6 - 9	N/A	N/A	N/A	N/A	6 - 9	2.2	14.3	2.1	2.3		
9 - 12	1.9	55.7	3.0	3.3	9 - 12	2.1	7.2	1.8	1.9		
12 - 15	3.3	96.2	3.5	4.1	12 - 15	N/A	N/A	N/A	N/A		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	2.8	83.8	3.4	3.8	Total Profile	2.5	14.9	2.5	2.5		

**Table 3.4 (cont'd) Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1232, 20-Jul-88, radar ground speed, Dryden Flight Research Facility**

Average magnitude difference = -0.4 m/s  
Average heading difference = -37.3 deg

Climb #3					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	
0 - 3	N/A	N/A	N/A	N/A	
3 - 6	N/A	N/A	N/A	N/A	
6 - 9	N/A	N/A	N/A	N/A	
9 - 12	1.6	6.8	1.6	0.5	
12 - 15	1.9	63.3	3.2	2.6	
15 - 18	2.2	44.1	4.8	2.2	
<b>Total Profile</b>	<b>2.0</b>	<b>52.5</b>	<b>4.0</b>	<b>2.4</b>	

**Table 3.5 Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1235, 01-Aug-88, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = -0.7 m/s  
Average heading difference = -33.0 deg

Average magnitude difference = -1.1 m/s  
Average heading difference = -2.9 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	0.8	82.3	1.3	1.3	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	1.1	89.1	2.4	2.3	3 - 6	N/A	N/A	N/A	N/A		
6 - 9	2.1	28.6	1.5	2.3	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	N/A	N/A	N/A	N/A	9 - 12	N/A	N/A	N/A	N/A		
12 - 15	N/A	N/A	N/A	N/A	12 - 15	2.0	9.7	2.1	1.5		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	1.7	46.8	2.2	2.0		
Total Profile	1.8	73.1	2.0	2.2	Total Profile	1.9	35.7	2.2	1.8		

Average magnitude difference = -2.3 m/s  
Average heading difference = -13.3 deg

Average magnitude difference = 3.9 m/s  
Average heading difference = -36.4 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	2.3	70.4	0.5	3.4		
3 - 6	N/A	N/A	N/A	N/A	3 - 6	2.3	147.7	1.5	6.0		
6 - 9	N/A	N/A	N/A	N/A	6 - 9	5.2	26.4	1.3	5.7		
9 - 12	3.1	12.4	1.5	3.6	9 - 12	5.4	14.7	1.9	5.9		
12 - 15	2.6	19.8	3.4	4.1	12 - 15	3.5	12.6	0.7	4.8		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	2.9	15.6	2.4	3.8	Total Profile	4.4	83.2	1.5	5.7		

**Table 3.5 (cont'd) Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1235, 01-Aug-88, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = -0.9 m/s  
Average heading difference = -15.5 deg

Climb #3					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	
0 - 3	N/A	N/A	N/A	N/A	
3 - 6	N/A	N/A	N/A	N/A	
6 - 9	N/A	N/A	N/A	N/A	
9 - 12	1.2	21.4	3.8	2.2	
12 - 15	2.1	21.3	4.4	2.6	
15 - 18	1.8	53.8	2.6	1.9	
Total Profile	2.0	40.6	3.6	2.2	

**Table 3.6 Jimsphere Release # 2 and F-104 wind profile RMS differences.  
Flight 1235, 01-Aug-88, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = -1.2 m/s  
Average heading difference = -13.1 deg

Average magnitude difference = -1.9 m/s  
Average heading difference = 13.2 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	0.6	87.8	1.3	1.7	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	1.5	95.7	2.1	1.2	3 - 6	N/A	N/A	N/A	N/A		
6 - 9	2.6	35.2	2.1	2.6	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	N/A	N/A	N/A	N/A	9 - 12	N/A	N/A	N/A	N/A		
12 - 15	N/A	N/A	N/A	N/A	12 - 15	3.8	31.3	3.5	4.0		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	2.0	68.2	3.2	2.5		
Total Profile	1.8	79.0	2.0	1.9	Total Profile	3.0	55.2	3.4	3.2		

Average magnitude difference = -1.7 m/s  
Average heading difference = -18.7 deg

Average magnitude difference = -4.0 m/s  
Average heading difference = -21.2 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	1.4	103.2	0.4	4.7		
3 - 6	N/A	N/A	N/A	N/A	3 - 6	3.0	134.9	1.3	4.8		
6 - 9	N/A	N/A	N/A	N/A	6 - 9	5.7	27.4	1.4	6.2		
9 - 12	1.9	17.3	1.6	3.8	9 - 12	4.2	19.7	1.0	6.1		
12 - 15	2.8	22.5	3.3	4.9	12 - 15	3.9	13.8	1.7	5.1		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	2.2	19.5	2.4	4.2	Total Profile	4.4	78.3	1.3	5.6		

**Table 3.6 (cont'd) Jimsphere Release # 2 and F-104 wind profile RMS differences.  
Flight 1235, 01-Aug-88, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = -1.5 m/s  
Average heading difference = -0.3 deg

Climb #3					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	
0 - 3	N/A	N/A	N/A	N/A	
3 - 6	N/A	N/A	N/A	N/A	
6 - 9	N/A	N/A	N/A	N/A	
9 - 12	2.5	28.0	5.8	2.5	
12 - 15	3.6	31.1	4.7	4.4	
15 - 18	2.0	69.9	3.4	1.9	
Total Profile	2.9	53.7	4.1	3.4	

**Table 3.7 Jimsphere Release # 1 and F-104 wind profile RMS differences.**  
**Flight 1235, 01-Aug-88, radar ground speed, Dryden Flight Research Facility**

Average magnitude difference = -0.3 m/s  
 Average heading difference = -4.0 deg

Average magnitude difference = -0.7 m/s  
 Average heading difference = 1.7 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	2.5	79.2	2.6	2.0	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	1.3	81.9	2.1	1.5	3 - 6	N/A	N/A	N/A	N/A		
6 - 9	1.4	29.7	1.7	1.3	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	N/A	N/A	N/A	N/A	9 - 12	N/A	N/A	N/A	N/A		
12 - 15	N/A	N/A	N/A	N/A	12 - 15	2.0	10.0	2.2	1.6		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	1.4	44.9	1.4	1.9		
Total Profile	1.6	68.3	2.1	1.5	Total Profile	1.7	34.4	1.8	1.8		

Average magnitude difference = 1.1 m/s  
 Average heading difference = -7.7 deg

Average magnitude difference = -1.2 m/s  
 Average heading difference = -27.9 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	1.7	76.6	2.2	2.1		
3 - 6	N/A	N/A	N/A	N/A	3 - 6	1.6	128.3	1.4	3.3		
6 - 9	N/A	N/A	N/A	N/A	6 - 9	2.3	21.6	1.0	2.7		
9 - 12	1.4	15.1	2.3	1.6	9 - 12	2.5	10.3	1.4	2.9		
12 - 15	3.4	22.3	5.1	2.3	12 - 15	0.9	7.0	0.7	1.8		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	2.4	18.2	3.6	1.9	Total Profile	2.1	72.5	1.3	2.9		

**Table 3.7 (cont'd.) Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1235, 01-Aug-88, radar ground speed, Dryden Flight Research Facility**

Average magnitude difference = -0.9 m/s  
Average heading difference = -8.4 deg

Climb #3					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	
0 - 3	N/A	N/A	N/A	N/A	
3 - 6	N/A	N/A	N/A	N/A	
6 - 9	N/A	N/A	N/A	N/A	
9 - 12	0.9	17.8	3.1	2.1	
12 - 15	1.9	17.6	3.4	2.7	
15 - 18	1.4	44.1	1.7	1.9	
Total Profile	1.6	33.3	2.7	2.3	

**Table 3.8 Jimsphere Release # 2 and F-104 wind profile RMS differences.  
Flight 1235, 01-Aug-88, radar ground speed, Dryden Flight Research Facility**

Average magnitude difference = -0.9 m/s  
Average heading difference = -0.4 deg

Average magnitude difference = -1.4 m/s  
Average heading difference = 17.8 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	2.4	82.6	3.0	1.8	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	1.7	66.8	1.9	1.2	3 - 6	N/A	N/A	N/A	N/A		
6 - 9	1.6	39.1	2.1	1.2	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	N/A	N/A	N/A	N/A	9 - 12	N/A	N/A	N/A	N/A		
12 - 15	N/A	N/A	N/A	N/A	12 - 15	3.6	30.7	3.6	3.5		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	1.7	73.1	2.6	2.6		
Total Profile	1.8	62.2	2.2	1.3	Total Profile	2.7	58.5	3.1	3.0		

Average magnitude difference = 1.7 m/s  
Average heading difference = -13.1 deg

Average magnitude difference = -1.3 m/s  
Average heading difference = -12.8 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	1.4	93.2	2.1	2.6		
3 - 6	N/A	N/A	N/A	N/A	3 - 6	1.2	109.6	1.1	2.1		
6 - 9	N/A	N/A	N/A	N/A	6 - 9	2.9	20.9	1.1	3.2		
9 - 12	2.1	16.7	3.2	1.6	9 - 12	1.5	14.3	1.3	3.0		
12 - 15	2.6	24.0	5.0	2.0	12 - 15	1.6	8.7	1.7	2.0		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	2.3	19.8	4.0	1.7	Total Profile	2.0	63.8	1.3	2.7		

**Table 3.8 (cont'd) Jimsphere Release # 2 and F-104 wind profile RMS differences.  
Flight 1235, 01-Aug-88, radar ground speed, Dryden Flight Research Facility**

Average magnitude difference = -1.5m/s  
Average heading difference = 6.8 deg

Climb #3					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	
0 - 3	N/A	N/A	N/A	N/A	
3 - 6	N/A	N/A	N/A	N/A	
6 - 9	N/A	N/A	N/A	N/A	
9 - 12	2.2	24.4	5.0	2.4	
12 - 15	3.4	29.5	3.8	4.5	
15 - 18	1.6	66.2	2.6	1.9	
<b>Total Profile</b>	<b>2.7</b>	<b>50.9</b>	<b>3.3</b>	<b>3.4</b>	

**Table 3.9 Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1283, 21-Apr-89, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = -1.1 m/s  
Average heading difference = 2.2 deg

Average magnitude difference = 0.0 m/s  
Average heading difference = -2.9 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	1.4	6.8	2.1	0.8	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	2.4	4.9	2.3	2.1	3 - 6	N/A	N/A	N/A	N/A		
6 - 9	3.5	5.6	4.4	2.3	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	2.6	3.9	3.2	2.0	9 - 12	N/A	N/A	N/A	N/A		
12 - 15	N/A	N/A	N/A	N/A	12 - 15	2.3	7.0	2.7	3.6		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	4.0	8.4	3.5	3.6		
Total Profile	2.8	5.3	3.3	2.0	Total Profile	3.4	7.8	3.2	3.6		

Average magnitude difference = -4.8 m/s  
Average heading difference = 1.7 deg

Average magnitude difference = -6.4 m/s  
Average heading difference = -1.3 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	N/A	N/A	N/A	N/A	3 - 6	6.5	2.9	4.5	4.9		
6 - 9	N/A	N/A	N/A	N/A	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	9.1	2.6	8.4	4.0	9 - 12	N/A	N/A	N/A	N/A		
12 - 15	3.3	5.6	3.6	2.8	12 - 15	N/A	N/A	N/A	N/A		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	6.1	4.7	5.8	3.3	Total Profile	6.5	2.9	4.5	4.9		

**Table 3.9 (cont'd) Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1283, 21-Apr-89, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = -2.3 m/s  
Average heading difference = 6.5 deg

Climb #3					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	
0 - 3	N/A	N/A	N/A	N/A	
3 - 6	N/A	N/A	N/A	N/A	
6 - 9	N/A	N/A	N/A	N/A	
9 - 12	N/A	N/A	N/A	N/A	
12 - 15	4.3	15.2	8.0	5.2	
15 - 18	N/A	N/A	N/A	N/A	
Total Profile	4.3	15.2	8.0	5.2	

**Table 3.10 Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1283, 21-Apr-89, radar ground speed, Dryden Flight Research Facility**

Average magnitude difference = -1.9 m/s  
Average heading difference = -0.5 deg

Average magnitude difference = -0.7 m/s  
Average heading difference = -5.6 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	1.5	5.6	2.0	1.0	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	7.0	12.8	3.9	9.3	3 - 6	N/A	N/A	N/A	N/A		
6 - 9	4.0	7.1	4.9	3.4	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	2.0	5.0	3.3	2.2	9 - 12	N/A	N/A	N/A	N/A		
12 - 15	N/A	N/A	N/A	N/A	12 - 15	2.6	8.5	2.8	4.7		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	4.0	9.9	3.8	3.6		
Total Profile	5.0	9.3	4.0	6.0	Total Profile	3.4	9.3	3.4	4.1		

Average magnitude difference = -2.7 m/s  
Average heading difference = 1.7 deg

Average magnitude difference = -3.2 m/s  
Average heading difference = -3.7 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	N/A	N/A	N/A	N/A	3 - 6	3.0	5.1	1.5	3.9		
6 - 9	N/A	N/A	N/A	N/A	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	7.2	3.1	6.7	3.1	9 - 12	N/A	N/A	N/A	N/A		
12 - 15	3.1	5.9	3.0	3.3	12 - 15	N/A	N/A	N/A	N/A		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	4.9	5.1	4.7	3.2	Total Profile	3.0	5.1	1.5	3.9		

**Table 3.10 (cont'd) Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1283, 21-Apr-89, radar ground speed, Dryden Flight Research Facility**

Average magnitude difference = -5.4 m/s  
Average heading difference = 1.1 deg

Average magnitude difference = -3.2 m/s  
Average heading difference = -3.7 deg

Climb #3						Descent #3					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	N/A	N/A	N/A	N/A	3 - 6	3.0	5.1	1.5	3.9		
6 - 9	N/A	N/A	N/A	N/A	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	N/A	N/A	N/A	N/A	9 - 12	N/A	N/A	N/A	N/A		
12 - 15	6.2	13.1	8.2	5.5	12 - 15	N/A	N/A	N/A	N/A		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	6.2	13.1	8.2	5.5	Total Profile	3.0	5.1	1.5	3.9		

**Table 3.11 Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1284, 25-Apr-89, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = -2.2 m/s  
Average heading difference = -1.9 deg

Average magnitude difference = -1.4 m/s  
Average heading difference = -5.1 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	3.6	18.8	2.3	3.6	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	2.3	13.1	1.3	2.9	3 - 6	N/A	N/A	N/A	N/A		
6 - 9	3.1	6.6	2.9	2.2	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	N/A	N/A	N/A	N/A	9 - 12	1.1	3.8	1.7	0.8		
12 - 15	N/A	N/A	N/A	N/A	12 - 15	2.3	7.4	1.7	3.2		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	2.9	12.3	2.2	2.8	Total Profile	2.0	6.5	1.7	2.7		

Average magnitude difference = -1.4 m/s  
Average heading difference = 7.8 deg

Average magnitude difference = -6.1 m/s  
Average heading difference = -2.5 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	N/A	N/A	N/A	N/A	3 - 6	5.5	14.5	3.1	5.4		
6 - 9	N/A	N/A	N/A	N/A	6 - 9	8.1	4.1	6.4	5.2		
9 - 12	3.0	8.5	4.8	2.0	9 - 12	5.2	5.5	5.1	3.2		
12 - 15	2.0	10.1	2.5	3.1	12 - 15	N/A	N/A	N/A	N/A		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	2.7	9.2	4.1	2.5	Total Profile	6.4	9.3	5.1	4.7		

**Table 3.11 (cont'd) Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1284, 25-Apr-89, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = 1.3 m/s  
Average heading difference = 2.8 deg

Climb #3					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	
0 - 3	N/A	N/A	N/A	N/A	
3 - 6	N/A	N/A	N/A	N/A	
6 - 9	N/A	N/A	N/A	N/A	
9 - 12	2.4	5.1	2.2	2.5	
12 - 15	N/A	N/A	N/A	N/A	
15 - 18	N/A	N/A	N/A	N/A	
Total Profile	2.4	5.1	2.2	2.5	

**Table 3.12 Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1284, 25-Apr-89, radar ground speed, Dryden Flight Research Facility**

Average magnitude difference = -0.9 m/s  
Average heading difference = -2.2 deg

Average magnitude difference = -0.8 m/s  
Average heading difference = -6.4 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	3.1	15.9	1.5	3.2	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	1.3	13.8	1.4	2.1	3 - 6	N/A	N/A	N/A	N/A		
6 - 9	2.5	6.7	2.5	2.1	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	N/A	N/A	N/A	N/A	9 - 12	1.0	5.3	2.1	1.1		
12 - 15	N/A	N/A	N/A	N/A	12 - 15	1.4	8.5	2.2	2.6		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	2.2	11.9	1.9	2.3	Total Profile	1.3	7.6	2.1	2.2		

Average magnitude difference = 1.2 m/s  
Average heading difference = 10.7 deg

Average magnitude difference = -3.0 m/s  
Average heading difference = -2.8 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	N/A	N/A	N/A	N/A	3 - 6	2.4	14.6	1.5	3.2		
6 - 9	N/A	N/A	N/A	N/A	6 - 9	5.3	5.1	4.5	3.6		
9 - 12	1.8	11.3	4.0	4.2	9 - 12	2.5	5.5	3.1	2.2		
12 - 15	3.8	14.2	1.8	5.5	12 - 15	N/A	N/A	N/A	N/A		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	2.7	12.5	3.3	4.8	Total Profile	3.7	9.5	3.3	3.1		

Table 3.12 (cont'd)

Jimsphere Release # 1 and F-104 wind profile RMS differences.  
 Flight 1284, 25-Apr-89, radar ground speed, Dryden Flight Research Facility

Average magnitude difference = -1.7 m/s  
 Average heading difference = -1.3 deg

Climb #3					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	
0 - 3	N/A	N/A	N/A	N/A	
3 - 6	N/A	N/A	N/A	N/A	
6 - 9	N/A	N/A	N/A	N/A	
9 - 12	2.6	4.1	2.1	2.5	
12 - 15	N/A	N/A	N/A	N/A	
15 - 18	N/A	N/A	N/A	N/A	
Total Profile	2.6	4.1	2.1	2.5	

**Table 3.13 Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1286, 20-Jul-89, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = -2.7 m/s  
Average heading difference = -3.6 deg

Average magnitude difference = -1.0 m/s  
Average heading difference = -10.2 deg

Climb #1						Descent #1								
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)
0 - 3	1.6	20.4	2.0	1.5	0 - 3	N/A	N/A	N/A	N/A	0 - 3	N/A	N/A	N/A	N/A
3 - 6	3.9	8.5	3.2	2.5	3 - 6	N/A	N/A	N/A	N/A	3 - 6	N/A	N/A	N/A	N/A
6 - 9	3.4	12.4	3.0	2.4	6 - 9	N/A	N/A	N/A	N/A	6 - 9	N/A	N/A	N/A	N/A
9 - 12	0.9	12.0	0.8	1.8	9 - 12	N/A	N/A	N/A	N/A	9 - 12	N/A	N/A	N/A	N/A
12 - 15	N/A	N/A	N/A	N/A	12 - 15	0.9	12.4	1.0	2.0	12 - 15	0.9	12.4	1.0	2.0
15 - 18	N/A	N/A	N/A	N/A	15 - 18	2.7	57.7	3.9	3.4	15 - 18	2.7	57.7	3.9	3.4
Total Profile	3.4	12.7	2.9	2.3	Total Profile	1.9	39.3	2.7	2.7	Total Profile	1.9	39.3	2.7	2.7

Average magnitude difference = 2.0 m/s  
Average heading difference = -9.0 deg

Average magnitude difference = -4.4 m/s  
Average heading difference = -8.9 deg

Climb #2						Descent #2								
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)
0 - 3	N/A	N/A	N/A	N/A	0 - 3	N/A	N/A	N/A	N/A	0 - 3	N/A	N/A	N/A	N/A
3 - 6	N/A	N/A	N/A	N/A	3 - 6	5.7	16.8	6.2	1.5	3 - 6	5.7	16.8	6.2	1.5
6 - 9	N/A	N/A	N/A	N/A	6 - 9	4.9	17.0	4.9	2.4	6 - 9	4.9	17.0	4.9	2.4
9 - 12	4.6	10.9	4.4	1.9	9 - 12	3.9	8.8	3.7	1.9	9 - 12	3.9	8.8	3.7	1.9
12 - 15	2.6	13.0	3.0	1.3	12 - 15	3.1	7.2	2.1	3.1	12 - 15	3.1	7.2	2.1	3.1
15 - 18	2.2	68.1	2.9	2.9	15 - 18	N/A	N/A	N/A	N/A	15 - 18	N/A	N/A	N/A	N/A
Total Profile	3.2	38.8	3.4	2.1	Total Profile	4.8	14.2	2.1	2.1	Total Profile	4.8	14.2	2.1	2.1

**Table 3.14 Jimsphere Release # 2 and F-104 wind profile RMS differences.  
Flight 1286, 20-Jul-89, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = -2.8 m/s  
Average heading difference = 2.2 deg

Average magnitude difference = -1.0 m/s  
Average heading difference = -7.2 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	1.8	16.5	1.7	1.5	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	3.4	10.4	3.0	2.1	3 - 6	N/A	N/A	N/A	N/A		
6 - 9	3.7	11.0	3.3	2.3	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	1.1	6.1	1.0	1.0	9 - 12	N/A	N/A	N/A	N/A		
12 - 15	N/A	N/A	N/A	N/A	12 - 15	1.4	6.0	1.2	1.5		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	2.2	26.0	2.4	2.2		
Total Profile	3.3	11.7	2.9	2.1	Total Profile	1.9	20.5	2.0	1.9		

Average magnitude difference = 1.7 m/s  
Average heading difference = -2.8 deg

Average magnitude difference = -4.5 m/s  
Average heading difference = -9.3 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	N/A	N/A	N/A	N/A	3 - 6	5.3	13.6	5.9	1.2		
6 - 9	N/A	N/A	N/A	N/A	6 - 9	5.1	18.1	5.1	2.5		
9 - 12	4.3	8.6	4.3	1.2	9 - 12	3.9	8.2	3.6	2.2		
12 - 15	2.3	9.6	2.5	1.3	12 - 15	3.8	3.9	3.2	2.5		
15 - 18	2.4	48.6	2.5	2.7	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	3.0	32.0	3.1	2.0	Total Profile	4.7	13.3	4.8	2.1		

**Table 3.15 Jimsphere Release # 3 and F-104 wind profile RMS differences.  
Flight 1286, 20-Jul-89, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = -3.3 m/s  
Average heading difference = 4.3 deg

Average magnitude difference = -0.8 m/s  
Average heading difference = 0.2 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	3.0	15.7	3.1	0.9	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	3.7	14.7	2.4	4.0	3 - 6	N/A	N/A	N/A	N/A		
6 - 9	4.4	14.9	3.9	2.8	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	2.1	3.4	1.9	0.9	9 - 12	N/A	N/A	N/A	N/A		
12 - 15	N/A	N/A	N/A	N/A	12 - 15	1.7	14.3	1.1	2.8		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	2.6	41.8	4.0	2.1		
Total Profile	3.8	14.7	3.2	3.1	Total Profile	2.2	32.2	3.1	2.4		

Average magnitude difference = 1.9 m/s  
Average heading difference = 0.8 deg

Average magnitude difference = -4.7 m/s  
Average heading difference = -7.6 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	N/A	N/A	N/A	N/A	3 - 6	4.8	14.0	4.9	1.8		
6 - 9	N/A	N/A	N/A	N/A	6 - 9	5.8	16.1	5.9	2.3		
9 - 12	4.5	11.6	4.4	1.6	9 - 12	4.1	5.8	3.8	1.9		
12 - 15	2.3	16.8	2.7	2.2	12 - 15	3.7	7.5	2.7	3.4		
15 - 18	2.9	57.6	4.0	2.9	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	3.2	37.3	3.7	2.3	Total Profile	4.8	12.2	4.7	2.2		

**Table 3.16 Jimsphere Release # 1 and F-104 wind profile RMS differences.  
Flight 1286, 20-Jul-89, radar ground speed, Dryden Flight Research Facility**

Average magnitude difference = -2.5 m/s  
Average heading difference = 1.4 deg

Average magnitude difference = -1.2 m/s  
Average heading difference = -14.6 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	1.3	24.7	1.6	1.9	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	4.0	10.7	2.9	3.2	3 - 6	N/A	N/A	N/A	N/A		
6 - 9	4.1	19.0	3.1	3.6	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	2.5	19.0	2.8	1.6	9 - 12	N/A	N/A	N/A	N/A		
12 - 15	N/A	N/A	N/A	N/A	12 - 15	1.6	13.9	1.6	2.2		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	2.8	53.8	4.0	3.5		
Total Profile	3.7	17.3	2.8	3.2	Total Profile	2.2	37.1	2.9	2.8		

Average magnitude difference = 0.9 m/s  
Average heading difference = -12.6 deg

Average magnitude difference = -2.1 m/s  
Average heading difference = -5.5 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	N/A	N/A	N/A	N/A	3 - 6	3.6	18.9	3.8	1.6		
6 - 9	N/A	N/A	N/A	N/A	6 - 9	3.5	15.0	3.2	2.3		
9 - 12	2.9	8.5	3.1	0.9	9 - 12	1.5	10.1	1.5	1.4		
12 - 15	1.5	14.1	2.2	2.0	12 - 15	0.4	6.4	0.7	1.5		
15 - 18	1.9	68.8	2.9	3.1	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	2.1	39.1	2.7	2.2	Total Profile	2.9	14.5	2.9	1.8		

**Table 3.17 Jimsphere Release # 2 and F-104 wind profile RMS differences.  
Flight 1286, 20-Jul-89, radar ground speed, Dryden Flight Research Facility**

Average magnitude difference = -2.5 m/s  
Average heading difference = 7.1 deg

Average magnitude difference = -1.3 m/s  
Average heading difference = -11.0 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	1.4	15.2	1.3	1.4	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	3.7	10.8	2.9	2.8	3 - 6	N/A	N/A	N/A	N/A		
6 - 9	4.4	17.8	3.5	3.6	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	2.7	19.1	3.1	1.8	9 - 12	N/A	N/A	N/A	N/A		
12 - 15	N/A	N/A	N/A	N/A	12 - 15	1.9	7.2	1.6	1.7		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	2.7	30.7	2.8	2.6		
Total Profile	3.8	15.0	3.0	3.0	Total Profile	2.4	24.2	2.3	2.3		

Average magnitude difference = 0.7 m/s  
Average heading difference = -7.5 deg

Average magnitude difference = -2.1 m/s  
Average heading difference = -5.9 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	1.4	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	N/A	N/A	N/A	2.8	3 - 6	3.1	13.2	3.4	1.2		
6 - 9	N/A	N/A	N/A	3.6	6 - 9	3.7	15.7	3.3	2.5		
9 - 12	2.6	13.9	2.9	1.8	9 - 12	1.3	7.3	1.2	1.2		
12 - 15	1.4	9.6	1.7	N/A	12 - 15	1.0	4.0	1.1	1.0		
15 - 18	2.5	52.7	2.4	N/A	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	2.2	35.0	2.4	3.0	Total Profile	2.8	12.0	2.7	1.7		

**Table 3.18 Jimsphere Release # 3 and F-104 wind profile RMS differences.  
Flight 1286, 20-Jul-89, radar ground speed, Dryden Flight Research Facility**

Average magnitude difference = -3.0 m/s  
Average heading difference = 9.2 deg

Average magnitude difference = -1.3 m/s  
Average heading difference = -11.0 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	2.7	14.3	2.7	0.9	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	4.0	16.9	2.4	4.6	3 - 6	N/A	N/A	N/A	N/A		
6 - 9	4.9	22.5	3.9	4.0	6 - 9	N/A	N/A	N/A	N/A		
9 - 12	3.2	18.6	3.5	1.7	9 - 12	N/A	N/A	N/A	N/A		
12 - 15	N/A	N/A	N/A	N/A	12 - 15	2.3	16.6	1.7	3.2		
15 - 18	N/A	N/A	N/A	N/A	15 - 18	2.9	43.7	4.4	2.4		
Total Profile	4.2	19.1	3.2	3.9	Total Profile	2.7	34.0	3.4	2.8		

Average magnitude difference = 0.9 m/s  
Average heading difference = -3.4 deg

Average magnitude difference = -2.3 m/s  
Average heading difference = -4.2 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	N/A	N/A	N/A	N/A		
3 - 6	N/A	N/A	N/A	N/A	3 - 6	2.6	16.4	2.5	2.2		
6 - 9	N/A	N/A	N/A	N/A	6 - 9	4.3	14.6	4.0	2.4		
9 - 12	2.8	13.2	3.1	1.5	9 - 12	1.5	5.1	1.4	1.0		
12 - 15	1.8	16.6	2.0	2.8	12 - 15	1.3	7.4	0.8	2.1		
15 - 18	2.9	61.1	3.9	3.4	15 - 18	N/A	N/A	N/A	N/A		
Total Profile	2.5	39.4	3.1	2.8	Total Profile	2.9	12.4	2.7	2.0		

**Table 3.19 Jimsphere Release # 1 and ER-2 wind profile RMS differences.  
Flight 1286, 20-Jul-89, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = 0.0 m/s  
Average heading difference = -6.2 deg

Average magnitude difference = -0.6 m/s  
Average heading difference = -13.4 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	0.9	3.6	0.8	0.5	0 - 3	1.0	14.4	1.3	1.1		
3 - 6	1.8	10.4	1.5	1.6	3 - 6	2.1	15.4	2.4	1.4		
6 - 9	1.7	16.1	1.3	2.2	6 - 9	1.9	19.3	2.5	2.2		
9 - 12	2.8	10.9	2.7	1.7	9 - 12	1.2	14.8	1.4	2.2		
12 - 15	1.8	8.6	1.8	1.4	12 - 15	1.3	10.8	1.4	1.7		
15 - 18	2.3	79.0	2.3	3.5	15 - 18	1.6	59.2	2.7	1.3		
Total Profile	2.1	30.8	3.2	2.1	Total Profile	1.7	23.8	2.1	1.8		

Average magnitude difference = -1.2 m/s  
Average heading difference = -6.2 deg

Average magnitude difference = -1.7 m/s  
Average heading difference = -4.0 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	2.9	15.5	3.1	1.3		
3 - 6	3.2	8.4	3.1	1.4	3 - 6	2.7	14.5	3.0	1.3		
6 - 9	3.1	12.5	2.7	2.3	6 - 9	3.1	14.6	3.6	1.8		
9 - 12	0.9	15.0	0.9	2.4	9 - 12	1.7	4.7	1.7	0.9		
12 - 15	1.2	15.5	1.1	3.0	12 - 15	1.1	8.7	1.1	1.4		
15 - 18	2.1	71.9	3.0	2.4	15 - 18	2.8	65.2	2.6	3.0		
Total Profile	2.4	28.8	2.3	2.2	Total Profile	2.4	26.6	2.6	1.7		

**Table 3.19 (cont'd) Jimsphere Release # 1 and ER-2 wind profile RMS differences.  
Flight 1286, 20-Jul-89, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = -0.4 m/s  
Average heading difference = 7.1 deg

Average magnitude difference = 0.5 m/s  
Average heading difference = -15.4 deg

Climb #3						Descent #3					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	2.6	24.0	2.6	1.8	0 - 3	2.8	48.0	3.1	3.4		
3 - 6	1.8	20.1	1.6	1.5	3 - 6	1.7	25.6	1.7	2.6		
6 - 9	1.6	10.9	1.4	1.6	6 - 9	1.4	19.6	1.6	3.0		
9 - 12	1.2	16.9	1.1	2.9	9 - 12	0.9	11.9	1.3	1.5		
12 - 15	1.8	19.9	1.3	2.9	12 - 15	1.7	13.4	2.6	1.9		
15 - 18	5.5	70.5	6.2	4.1	15 - 18	1.8	61.7	2.2	2.7		
Total Profile	2.5	30.2	2.6	2.6	Total Profile	2.4	30.0	2.1	2.4		

**Table 3.20 Jimsphere Release # 2 and ER-2 wind profile RMS differences.  
Flight 1286, 20-Jul-89, INS ground speed, Dryden Flight Research Facility**

Climb #1		Descent #1							
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)
0 - 3	2.1	13.8	2.0	1.0	0 - 3	2.2	12.1	2.2	1.1
3 - 6	2.0	9.8	1.7	1.6	3 - 6	2.8	15.4	3.0	1.9
6 - 9	2.2	14.3	1.8	2.2	6 - 9	2.3	21.2	3.0	2.4
9 - 12	2.8	8.9	2.8	1.2	9 - 12	1.2	17.0	1.3	2.7
12 - 15	1.7	7.4	1.8	1.2	12 - 15	1.9	7.6	1.6	1.7
15 - 18	2.2	81.0	3.0	3.6	15 - 18	1.6	56.6	2.8	2.4
Total Profile	2.2	31.3	2.2	2.0	Total Profile	2.1	23.8	2.4	2.2

Average magnitude difference = 0.1 m/s  
Average heading difference = 0.0 deg

Average magnitude difference = -0.9 m/s  
Average heading difference = -11.0 deg

Climb #2		Descent #2							
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)
0 - 3	N/A	N/A	N/A	N/A	0 - 3	4.0	13.9	3.9	1.8
3 - 6	3.4	11.1	1.1	1.0	3 - 6	2.8	11.4	3.2	1.3
6 - 9	3.4	9.6	1.4	1.6	6 - 9	3.4	14.9	3.9	1.7
9 - 12	0.9	12.8	0.7	2.2	9 - 12	2.0	7.0	2.8	1.6
12 - 15	1.2	20.9	1.1	3.0	12 - 15	1.8	5.3	1.8	1.0
15 - 18	1.9	51.3	5.3	4.1	15 - 18	2.4	40.9	2.3	2.5
Total Profile	2.5	22.7	2.2	2.4	Total Profile	2.6	19.2	2.3	2.5

Average magnitude difference = -1.2 m/s  
Average heading difference = 7.2 deg

Average magnitude difference = -1.8 m/s  
Average heading difference = -2.4 deg

**Table 3.20 (cont'd) Jimsphere Release # 2 and ER-2 wind profile RMS differences.  
Flight 1286, 20-Jul-89, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = -0.5 m/s  
Average heading difference = 6.6 deg

Average magnitude difference = 0.5 m/s  
Average heading difference = -12.6 deg

Climb #3						Descent #3					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	0.7	15.7	0.6	0.8	0 - 3	1.7	34.2	2.0	1.8		
3 - 6	1.1	11.1	1.1	1.0	3 - 6	2.2	20.5	1.8	2.7		
6 - 9	1.8	9.6	1.4	1.6	6 - 9	1.3	19.4	1.7	2.9		
9 - 12	0.8	12.8	0.7	2.2	9 - 12	1.0	13.8	1.3	2.0		
12 - 15	1.5	20.9	1.1	3.0	12 - 15	1.2	12.4	1.9	1.8		
15 - 18	4.8	51.3	5.3	4.1	15 - 18	3.0	42.3	2.4	3.7		
Total Profile	2.2	22.7	2.2	2.4	Total Profile	1.9	24.0	1.8	2.6		

**Table 3.21 Jimsphere Release # 3 and ER-2 wind profile RMS differences.  
Flight 1286, 20-Jul-89, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = -0.2 m/s  
Average heading difference = -0.8 deg

Average magnitude difference = -1.0 m/s  
Average heading difference = -10.3 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	2.8	33.5	2.9	1.6	0 - 3	3.7	24.1	3.8	1.2		
3 - 6	2.5	14.7	2.0	3.1	3 - 6	2.9	19.3	2.9	2.2		
6 - 9	2.7	20.7	2.0	3.0	6 - 9	2.8	20.0	3.5	2.4		
9 - 12	2.9	9.5	2.9	1.3	9 - 12	1.3	15.8	1.3	2.6		
12 - 15	2.2	9.1	2.0	1.8	12 - 15	2.0	12.0	1.5	2.5		
15 - 18	2.6	87.3	3.8	4.0	15 - 18	2.2	58.4	3.1	2.5		
Total Profile	2.6	33.6	2.5	4.0	Total Profile	2.4	24.8	2.6	2.4		

Average magnitude difference = -1.3 m/s  
Average heading difference = 7.9 deg

Average magnitude difference = -2.0 m/s  
Average heading difference = -0.7 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	N/A	N/A	N/A	N/A	0 - 3	5.9	26.3	5.9	1.9		
3 - 6	3.5	13.4	3.1	2.8	3 - 6	2.9	14.0	2.8	1.9		
6 - 9	4.1	16.1	3.6	2.8	6 - 9	4.1	15.8	4.7	1.9		
9 - 12	1.5	15.2	1.7	2.2	9 - 12	2.3	10.0	2.2	1.7		
12 - 15	1.3	12.6	1.1	2.2	12 - 15	1.8	8.2	1.4	1.8		
15 - 18	2.6	63.2	3.5	2.5	15 - 18	1.8	40.1	1.8	2.3		
Total Profile	2.8	26.1	2.7	2.5	Total Profile	2.9	19.8	3.0	1.9		

**Table 3.21 (cont'd) Jimsphere Release # 3 and ER-2 wind profile RMS differences.  
Flight 1286, 20-Jul-89, INS ground speed, Dryden Flight Research Facility**

Average magnitude difference = -0.6 m/s  
Average heading difference = 8.3 deg

Average magnitude difference = -0.3 m/s  
Average heading difference = -11.0 deg

Climb #3						Descent #3					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	1.1	16.4	1.1	0.7	0 - 3	1.9	34.6	1.7	1.9		
3 - 6	1.6	15.0	1.7	1.7	3 - 6	2.0	25.4	1.7	2.5		
6 - 9	2.4	14.3	2.0	2.1	6 - 9	1.7	21.4	2.3	3.2		
9 - 12	1.0	13.8	1.0	2.3	9 - 12	1.4	13.7	1.6	1.9		
12 - 15	1.5	18.1	1.3	2.4	12 - 15	1.7	17.1	2.2	2.7		
15 - 18	4.4	42.4	4.5	3.5	15 - 18	2.3	45.7	2.6	2.7		
Total Profile	2.2	20.7	2.2	2.4	Total Profile	1.8	26.1	2.1	2.6		

**Table 3.22 Jimsphere Release # 1 and ER-2 wind profile RMS differences.  
31-Jul-89, INS ground speed, NASA Kennedy Space Center**

Average magnitude difference = 2.8 m/s  
Average heading difference = -1.8 deg

Average magnitude difference = 2.1 m/s  
Average heading difference = 0.2 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	1.3	132.6	1.0	2.0	0 - 3	0.6	53.0	0.9	1.1		
3 - 6	1.6	20.6	1.5	1.3	3 - 6	1.2	19.6	1.1	1.7		
6 - 9	2.6	77.7	3.2	1.2	6 - 9	1.8	76.2	1.8	3.0		
9 - 12	6.8	19.2	7.6	3.5	9 - 12	5.6	8.7	4.9	3.8		
12 - 15	4.8	10.0	2.4	4.9	12 - 15	5.2	12.9	5.3	3.1		
15 - 18	4.3	16.6	3.4	3.9	15 - 18	2.4	20.8	4.4	3.3		
Total Profile	4.4	43.8	4.2	3.2	Total Profile	3.7	38.9	3.8	3.0		

Average magnitude difference = 0.5 m/s  
Average heading difference = -15.8 deg

Average magnitude difference = 1.8 m/s  
Average heading difference = -16.9 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	1.2	122.6	2.0	1.9	0 - 3	2.0	44.5	1.7	1.6		
3 - 6	2.0	41.6	2.4	1.3	3 - 6	1.2	20.9	1.5	1.0		
6 - 9	1.5	64.3	2.9	2.7	6 - 9	2.0	61.4	2.9	1.7		
9 - 12	2.2	20.5	4.9	4.1	9 - 12	4.8	17.7	6.4	2.1		
12 - 15	2.9	14.2	3.5	4.6	12 - 15	1.9	7.4	2.6	1.7		
15 - 18	4.9	30.0	5.2	4.6	15 - 18	4.6	32.8	4.6	5.5		
Total Profile	2.8	41.9	3.8	3.6	Total Profile	3.1	34.2	3.9	2.5		

**Table 3.23 Jimsphere Release # 2 and ER-2 wind profile RMS differences.  
31-Jul-89, INS ground speed, NASA Kennedy Space Center**

Average magnitude difference = 2.6 m/s  
Average heading difference = 17.6 deg

Average magnitude difference = 1.9 m/s  
Average heading difference = 4.5 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	0.7	119.8	1.3	1.4	0 - 3	0.5	43.7	0.6	1.3		
3 - 6	1.7	32.4	2.7	0.9	3 - 6	1.4	14.5	1.2	1.3		
6 - 9	2.8	77.3	3.5	1.5	6 - 9	1.7	52.0	1.9	3.2		
9 - 12	6.4	14.5	6.2	4.1	9 - 12	5.3	7.6	3.7	4.3		
12 - 15	5.9	14.3	1.6	6.9	12 - 15	6.2	10.9	4.6	5.0		
15 - 18	3.6	16.7	2.3	3.3	15 - 18	2.7	20.8	3.8	3.1		
Total Profile	4.5	44.1	3.7	3.3	Total Profile	3.9	28.0	3.2	3.6		

Average magnitude difference = 0.3 m/s  
Average heading difference = -8.5 deg

Average magnitude difference = 1.7 m/s  
Average heading difference = -11.7 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	0.8	139.6	2.1	1.2	0 - 3	1.7	47.8	1.2	2.2		
3 - 6	1.3	34.7	1.7	1.3	3 - 6	1.1	17.7	0.9	1.3		
6 - 9	1.5	46.0	2.8	2.0	6 - 9	2.3	78.2	3.1	2.1		
9 - 12	2.0	16.9	3.8	3.5	9 - 12	4.3	13.7	5.1	2.3		
12 - 15	2.4	8.9	2.5	3.0	12 - 15	3.0	5.8	2.2	2.7		
15 - 18	3.8	34.1	4.3	2.9	15 - 18	3.3	26.4	3.7	3.9		
Total Profile	2.2	35.8	3.0	2.6	Total Profile	2.9	39.6	3.2	2.4		

**Table 3.24 Jimsphere Release # 3 and ER-2 wind profile RMS differences.  
31-Jul-89, INS ground speed, NASA Kennedy Space Center**

Average magnitude difference = 2.2 m/s  
Average heading difference = 11.2 deg

Average magnitude difference = 1.6 m/s  
Average heading difference = 2.1 deg

Climb #1					Descent #1				
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)
0 - 3	1.0	112.5	1.9	1.5	0 - 3	0.8	30.4	0.8	0.9
3 - 6	2.2	45.8	3.6	1.0	3 - 6	1.8	24.3	2.0	1.3
6 - 9	2.2	51.6	2.5	1.4	6 - 9	1.7	75.1	1.8	3.4
9 - 12	6.5	8.2	4.7	5.0	9 - 12	5.5	12.8	3.8	5.1
12 - 15	5.9	18.9	1.6	7.7	12 - 15	6.6	9.5	4.1	5.8
15 - 18	3.4	13.4	1.8	3.4	15 - 18	2.9	16.7	3.2	2.7
Total Profile	4.5	37.7	3.1	4.5	Total Profile	4.2	37.5	3.0	4.0

Average magnitude difference = -0.1 m/s  
Average heading difference = -3.2 deg

Average magnitude difference = 1.3 m/s  
Average heading difference = -2.3 deg

Climb #2					Descent #2				
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)
0 - 3	1.0	154.3	2.6	1.1	0 - 3	1.3	38.8	0.8	2.0
3 - 6	1.1	38.7	1.5	1.3	3 - 6	1.1	26.9	1.4	1.3
6 - 9	1.4	64.9	2.0	2.2	6 - 9	1.6	31.6	1.8	1.5
9 - 12	2.0	11.0	2.6	2.8	9 - 12	4.4	9.1	4.3	3.0
12 - 15	2.1	7.1	2.0	2.6	12 - 15	2.6	6.8	1.2	3.1
15 - 18	3.6	21.7	3.4	2.7	15 - 18	2.7	22.0	2.5	3.4
Total Profile	2.1	41.5	2.3	2.3	Total Profile	2.7	22.4	2.5	2.5

**Table 3.25 Jimsphere Release # 7 and ER-2 wind profile RMS differences.  
08-Aug-89, INS ground speed, NASA Kennedy Space Center**

Average magnitude difference = -0.8 m/s  
Average heading difference = 0.2 deg

Average magnitude difference = 1.1 m/s  
Average heading difference = 23.3 deg

Climb #1						Descent #1					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	0.7	2.1	0.7	0.2	0 - 3	0.8	9.8	0.6	0.9		
3 - 6	2.1	13.6	1.6	1.1	3 - 6	1.2	14.2	1.6	0.9		
6 - 9	1.0	18.0	2.0	2.3	6 - 9	2.7	16.0	1.6	2.7		
9 - 12	2.3	17.3	1.8	2.6	9 - 12	3.7	63.7	3.4	4.0		
12 - 15	1.4	73.7	1.5	3.5	12 - 15	2.5	95.4	2.6	3.7		
15 - 18	3.3	45.9	2.9	3.5	15 - 18	3.6	66.8	2.8	4.9		
Total Profile	2.0	40.0	1.9	2.3	Total Profile	2.8	58.9	2.4	3.4		

Average magnitude difference = -0.6 m/s  
Average heading difference = 2.2 deg

Average magnitude difference = 1.2 m/s  
Average heading difference = -14.0 deg

Climb #2						Descent #2					
altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)	altitude (km)	speed (m/s)	heading (deg)	North component (m/s)	East component (m/s)		
0 - 3	2.4	18.7	1.4	2.6	0 - 3	1.0	18.5	0.4	1.8		
3 - 6	1.5	29.8	3.0	2.1	3 - 6	1.4	26.2	2.4	1.6		
6 - 9	1.7	23.3	2.8	1.9	6 - 9	2.8	31.9	3.3	2.9		
9 - 12	2.1	22.6	2.1	1.9	9 - 12	3.7	45.4	2.9	3.4		
12 - 15	2.3	15.1	1.5	2.2	12 - 15	1.1	40.1	2.5	1.5		
15 - 18	1.7	18.3	1.9	1.7	15 - 18	1.9	43.7	4.4	2.4		
Total Profile	1.9	22.5	2.3	2.0	Total Profile	2.4	36.9	2.9	2.5		

**Table 4.1 Calculated winds fraction with equivalent quality to the Jimsphere winds.**

	F-104	F-104	ER-2
	Radar ground speed	INS ground speed	INS ground speed
3 km Layers	69 %	56 %	76 %
Profiles	45 %	35 %	56 %



# Report Documentation Page

1. Report No.		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle  (Aerospace Vehicle Atmospheric Environment Studies)  "Analysis of Wind Profile Measurements From An Instrumented Aircraft"				5. Report Date November 30, 1990	
				6. Performing Organization Code FWG Associates, Inc.	
7. Author(s) Terry S. Paige Patrick J. Murphy Walter Frost				8. Performing Organization Report No.	
				10. Work Unit No.	
9. Performing Organization Name and Address  FWG Associates, Inc. UTSI Research Park, Bldg. # 1 Tullahoma, TN 37388				11. Contract or Grant No. NAS8-37377	
				13. Type of Report and Period Covered Interim Final Report Thru 30 Nov 90	
12. Sponsoring Agency Name and Address NASA Washington, DC 20546-0001 National Aeronautics and Space Administration George C. Marshall Space Flight Center Marshall Space Flight Center, AL 35812				14. Sponsoring Agency Code	
				15. Supplementary Notes	
16. Abstract  An evaluation of wind profile measurements from instrumented aircraft, by comparisons with wind profiles derived from Jimsphere trajectories, is given. The two aircraft which participated in the study were an F-104 from Dryden Flight Research Facility and an ER-2 from Ames Research Center.					
17. Key Words (Suggested by Author(s))  Space Shuttle ascent stage, wind velocity measurement, wind profiles, research aircraft				18. Distribution Statement  Unclassified - Unlimited	
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of pages 155	22. Price